BULLETIN 537 AUGUST, 1934

The Gladiolus Thrips

Taeniothrips gladioli M. & S.

E. A. Herr

OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio

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THE GLADIOLUS THRIPS

Taeniothrips gladioli M. & S.

E. A. HERR[1]

INTRODUCTION

The first authentic record of the presence of the gladiolus thrips in Ohio consists of specimens collected in Cleveland during the summer of 1929. During the same year, this insect was found in the vicinity of the Vineland Station, Ontario, Canada. Specialists in this group of insects at that time were not able to recognize the species. Upon further study, it developed that the insect was a new one which had not been previously given a scientific name. The insect was described and named by Moulton and Steinwenden (17) in January, 1931, at which time the name *Taeniothrips gladioli* M. & S. was assigned to this particular species.

The original or native home of this insect is a matter of conjecture. Some entomologists feel that it may be a European form, accidentally introduced into America on gladiolus corms. This belief is substantiated by the fact that certain species[2] in Europe so closely resemble the American species that they are distinguished from it with difficulty.

REVIEW OF LITERATURE

As mentioned before, the adult insect was described and named by Moulton and Steinwenden (17) in 1931. Since that time Dustan and Brice (3, 4) of Canada have given some suggested control measures both for the corms in storage and for the plants growing in the field. Weigel, Smith, Richardson, and Nelson of the Bureau of Entomology, United States Department of Agriculture, (18, 19, 20, 21, 22, 24, 25) have published regarding the life history and control of this pest. Five other workers—McDaniel (15, 16) of Michigan, Hamilton (11, 12) of New Jersey, Bourne and Davis (2) of Massachusetts, and Gambrel (9, 10) of New York—have made contributions. Most of these publications are in the form of mimeographed sheets, preliminary reports, and papers in scientific journals.

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[1]Acknowledgments—The writer desires to express his appreciation to Prof. J. S. Houser, Chief of the Department of Entomology, for his counsel and suggestions and his untiring efforts during the preparation of this bulletin. The writer has also been aided and encouraged by a number of co-investigators; namely, Doctors L. L. Huber and C. R. Neiswander have given assistance in plot technique and analysis of data; A. M. Cody and Ben Marshall aided in collecting the data. Dr. G. A. Filinger was first to find the insect in Ohio and did some preliminary experimental work in 1931. Because graduate credit was allowed for the work attending this investigation, Prof. R. C. Osburn, of the Ohio State University, previewed the manuscript before publication.

For the determination of species of thrips taken on gladiolus during the progress of the work, the writer is indebted to Dr. J. R. Watson, Entomologist of the Florida Agricultural Experiment Station. Mr. P. T. Ulman, Assistant State Entomologist of Indiana, Auburn, Indiana, contributed many corms for the greenhouse and field tests. Several Ohio gladiolus growers also contributed corms and gave splendid cooperation during the progress of this problem; namely, C. R. Hills, Avon Lake, Ohio; R. C. Bellard, Ravenna, Ohio; Lake Land Gladfields, Amherst, Ohio; and Ashlo Gardens, Ashland, Ohio.

[2]*Thrips ebneri* Karny and *T. angusticeps* Uzel.

HISTORY OF THE PROBLEM

After the first appearance of this insect in America, it spread like wildfire. Serious damage was reported in Ontario, Canada, in 1929. Considerable injury occurred in Ohio as early as 1930, and during the past 3 years most of the gladiolus plantings all over the United States were menaced by this pest.

In view of the extensive commercial value of the gladiolus and the extreme popularity of the flowers with home gardeners, it was decided at the Ohio Agricultural Experiment Station to give this problem major standing from the research point of view. Accordingly, investigational work was started on this pest in 1931 and has continued until the present time.

METHODS

Inasmuch as the gladiolus thrips is a new insect pest for Ohio, a particular attempt has been made in this investigation to parallel biological and control studies. The former is needed as a background for the latter, and both are of interest to entomologists and growers. All phases of the work have been conducted on as comprehensive a basis as the facilities permitted.

In the major experiments recorded herein, the difference necessary between treatment means to give significant odds was determined in accordance with the methods outlined by R. A. Fisher (7). Odds of 19 to 1 were used in all the tests of significance.

DISTRIBUTION

According to present information, based upon specimens sent to and identified by Dr. J. R. Watson of the Florida Experiment Station, upon the paper by Weigel and Smith (24), and upon the records of the Insect Pest Survey (14), this thrips is now known to occur in California, Canada, Connecticut, Delaware, District of Columbia, Florida, Georgia, Hawaii, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, Rhode Island, Tennessee, Virginia, West Virginia, and Wisconsin.

Due to the ease with which gladiolus corms can be transported long distances and to the fact that this pest infests the corms, it is not surprising that the insect has become widespread in distribution in such a comparatively short time. It should also be mentioned that gladiolus growers do considerable exchanging, especially in times of depression, in order to obtain a start of the new, worthwhile varieties. This undoubtedly has aided materially in the distribution of this pest.

ECONOMIC IMPORTANCE

As has been stated previously, gladioli are grown extensively in commercial plantings as well as in home gardens. In Ohio it is not uncommon to see fields of 5, 10, or 20 acres, and fields ranging from 1 to 5 acres are quite numerous. Moreover, they are highly favored among the flowers grown in the home garden.

Since it is possible for the gladiolus thrips to ruin the crop completely, the monetary loss in Ohio during the past 4 years has been terrific, particularly during the earlier part of this period before means were devised for the control of the insect. On the basis of 75,000 corms per acre, with each corm producing one salable spike and the flowers selling at 50 cents per dozen, the loss per acre on cut flowers alone may amount to over $3000.00 for each acre lost. In addition to the loss from cut flowers, the damage to the foliage caused by the thrips results in stunted corm growth; hence, the loss from this source, by reason of fewer high quality corms produced, is another item of no small moment to the grower.

DESCRIPTION OF VARIOUS STAGES OF THE INSECT

The various stages of the gladiolus thrips consist of the egg, two larval instars or stages, two pupal instars, and the adult.

DESCRIPTION OF THE EGG

The egg is opaque and kidney-shaped and measures about 0.35 mm. in length and 0.19 mm. in diameter. During the growing season the eggs are laid in the leaves of the green plant, and under favorable conditions they are deposited in the tissues of the corms in storage. When a heavy infestation prevails on the foliage, it is possible to raise a vein of a leaf carefully and observe with the aid of a microscope a long row of eggs.

DESCRIPTION OF THE LARVA

Upon hatching, the larva, while still within the unbroken, flexible shell, thrusts the end of the egg which contains the fore part of its body through the tissues of the plant. The shell soon bursts and the milky white larva emerges. At this time the insect is about 0.5 mm. in length and 0.15 mm. broad. In other words, it is almost microscopic in size. It may wander about a while but it soon starts feeding. Soon thereafter its color changes to a lemon yellow, which is maintained throughout the second larval and both the pupal stages. If the larva is feeding on green foliage, the green chlorophyll may be seen through its body wall; or, if it is feeding on a red flower, for example, the red pigment of the petals is apparent.

In the molting or skin-shedding process, which marks the passing from the first to the second larval stage, the insect attaches the head end of the body to a surface and then, after the skin splits in a line down the back, the insect pulls itself out of the old skin. The second instar larva eats voraciously and consequently grows rapidly in size, finally becoming about as large as the winged adult. When growth is complete, the skin is shed in the manner of the first-stage larva and the insect is then in the first pupal stage.

During both the first and second larval stages, the insect is capable of actively crawling about over the plant, but just previous to the acts of molting it spends short, quiescent periods.

DESCRIPTION OF THE PUPA

The first pupal instar may be distinguished by the appearance of the short wing-pads. The antennae project forward from the head as in both larval instars. This instar measures 1.11 mm. in length and 0.31 mm. in width across the thorax.

The second pupal instar may be distinguished by the appearance of the long wing-pads. The antennae are folded back flatly on the head. This instar measures 1.18 mm. in length and 0.32 mm. in width across the thorax.

During both pupal instars, the insect is quiescent and moves only when disturbed. No food is taken throughout the entire pupal period.

DESCRIPTION OF THE ADULT

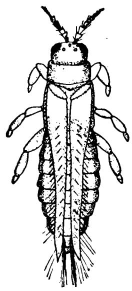

Fig. 1.—Adult female thrips. Enlarged 23 x

When the adult emerges, it is whitish in color but soon turns dark brown and starts feeding. The male is smaller than the female (Fig. 1) and slightly lighter in color. Moulton and Steinwenden (17) state that the males measure 1.2 mm. in length and the females 1.65 mm. The fore wings of both male and female are brown but the basal third is a lighter shade. When the wings are folded over the back, this light basal third of the fore wing can readily be seen. The antennae are uniformly brown, except the third segment, which is lighter in color. These general characteristics should aid in distinguishing this species from some of the other more common thrips found in Ohio.

Ordinarily, if a thrips infesting gladiolus meets these general specifications and is *very abundant*, there is little likelihood that it is other than the true gladiolus thrips. For the sake of completeness, however, it may be said that the following species of thrips have been recorded from the gladiolus plant:

Aeolothrips fasciatus Lind.
Chirothrips manicatus Haliday
Frankliniella fusca Hinds[3]
Frankliniella nervosa Uzel
Frankliniella occidentalis Perg.
Frankliniella tritici Fitch[3]
Frankliniella tritici var. *bispinosa* Morgan
Heliothrips femoralis Reuter[3]
Limothrips cerealium Haliday
Sericothrips cingulatus Hinds
Thrips tabaci Lind.[3]

PARTHENOGENESIS AND MATING

Usually both sexes of the gladiolus thrips are present, but ordinarily the females outnumber the males. When 200 pupae were collected at random from infested gladiolus foliage and reared to adulthood, 50 per cent were females and 50 per cent males. Smith and Nelson (22) reported that only 32.5 per cent of the 874 reared offspring of mated females were males. Because of the polygamous habits of the males it is thought that very few unfertilized females occur normally.

When the progeny of 20 unmated females were reared to adulthood, all were males. Smith and Nelson (22) likewise found this true and, at the same time, discovered that, when unfertilized females were mated with their own offspring, the eggs laid subsequent to this mating produced both males and females. Thus, one female could initiate an infestation on stored corms or on growing plants. This fact is quite significant.

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[3]These species have been collected by the writer. The other species have been taken by other workers (24).

GENERAL DISCUSSION OF LIFE HISTORY

The prime object of an investigation of this sort is to determine effective control measures for the pest under consideration, but, as is true with most harmful insects, the chances of developing a satisfactory control are enhanced greatly if an intimate understanding of the insect itself and its ways is obtained.

Because the gladiolus thrips may multiply on corms in storage as well as on the foliage of growing plants, any study of the seasonal development must take into consideration both conditions. On account of the small size and secretive habits of the insect, precise life history studies are impossible unless the insects are confined in some sort of enclosure. It is felt that the confinement necessary does not greatly interfere with the behavior of the thrips when the studies concern its activities on corms in storage. The confinement of the insects on growing plants introduces a more serious degree of artificiality, but, if such studies are supplemented by field observations, it is thought the more essential features are dependable.

HIBERNATION IN STORAGE

The first authentic evidence that this pest hibernates on the corms in storage was obtained during the early spring of 1931. A grower brought infested corms to the Experiment Station and specimens from these corms were determined by Dr. J. R. Watson as *Taeniothrips gladioli* M. & S.

Uninfested corms were placed with the original lot of infested ones and allowed to remain 2 days. At the end of this period the new corms were removed and all insects that were present were destroyed. A little later the corms were found to be infested with first-stage larvae, thus proving that eggs had been laid when the adult insects were present. Subsequently, many observations have been made in which all stages of the insect were found to be present on corms in storage.

During the fall of 1931, 30 infested corms were deposited in a cloth-covered lantern globe and placed in a grower's storage. When examined in April, 1932, it was found that 47.6 per cent of the insects had survived and that larvae were present also. Thus, it is apparent that not only does the insect hibernate on corms in storage, but, as will be shown later, reproduction may be continuous through the storage period if favorable conditions prevail.

HIBERNATION IN THE FIELD

Many attempts by the writer have failed to find this pest hibernating in piles of gladiolus tops left in the field over winter. In some cases, corms were intentionally left in the ground all winter to determine if the insects would move to them in late fall from the heavily infested foliage and survive. If any insects migrated to the corms, they died before spring because no living insects could be found. In the majority of cases, the corms were rotten.

In an effort to obtain definite information regarding the winter habitat of the gladiolus thrips under out-of-door conditions, five special hibernating cages (Figs. 2 and 3) were set up at Wooster, Ohio, during the fall of 1932. The cages consisted of a wooden framework, which, with the exception of the bottom, was tightly covered with closely woven muslin. A 6-inch strip of metal which extended downward from the bottom of the cage was buried in the ground. Access to the interior of the cage for observational purposes was made through a door at one end.

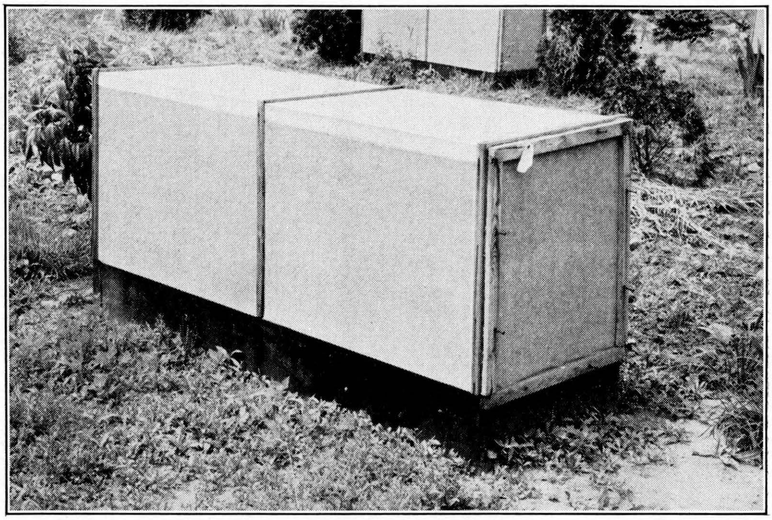


Fig. 2.—Cage used in outdoor hibernation studies of gladiolus thrips

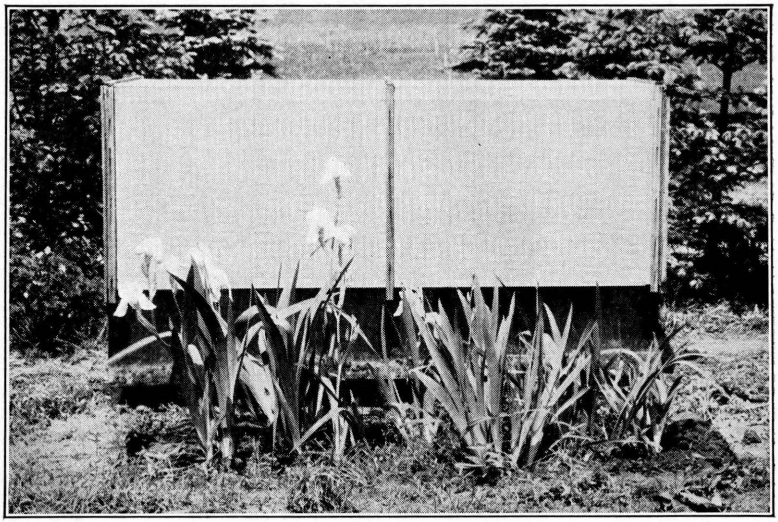


Fig. 3.—Cage removed from iris used in hibernation studies of gladiolus thrips

In each cage was established a different type of hibernating condition. One cage was set over a thick mass of June grass. In the second, several clumps of Japanese and German iris were planted, and a third one contained several species of other perennial flowers. The fourth cage contained a very thin layer of infested gladiolus tops, and the last was entirely filled with the same material. A large number of living thrips was liberated in each cage.

During April and May, 1933, a careful examination was made of the plant material in each cage for the presence of living thrips. None was found. Potted plants of gladiolus free from thrips were placed in each cage and allowed to remain 2 weeks. In no instance did these develop an infestation. The evidence seemed conclusive, therefore, that the thrips did not overwinter out-of-doors in 1932-1933. The winter was not severe; hence, it seems safe to assume that even under favorable conditions this insect cannot survive out-of-doors in Ohio. In addition to this evidence, Weigel and Smith (24) reported that this insect was unable to survive out-of-doors in Washington, D. C., during the winter of 1931-1932.

DEVELOPMENT IN STORAGE

It has been shown in previous paragraphs that the gladiolus thrips not only is able to survive on stored corms but that multiplication may occur during the winter months. At this point will be discussed the influence of storage conditions, with special reference to temperature, which affect the rate of development of the thrips on corms in storage. It is to be regretted that equipment was not available for a critical study of the effect of different degrees of moisture as well. However, the temperature factor is more easily controlled than that of moisture in the storages of growers; hence, it is felt that information concerning temperature conditions may be of much greater practical usefulness.

THE EGG

In determining the developmental period of the egg on stored corms, difficulties were encountered in the drying or hardening of the surface of the cormels upon which the eggs had been deposited. This interfered with hatching. For this reason, large, growing gladiolus plants were used instead. The following procedure was employed. A transparent cylinder 5 inches long and 1 inch in diameter, open at both ends, was placed over the tip of the growing plant and supported in position by a wooden stake. Cotton was inserted in the bottom end, surrounding the gladiolus leaf, and 25 female thrips which had had access to males were liberated in the tube. The top of the tube was then closed with a cotton plug. After 24 hours, the adult thrips were removed and the tube closed to prevent any possibility of further egg laying by other thrips which might accidentally find the plants. Three plants treated in this manner were placed in each of five cabinets in which were maintained temperatures of 50°, 59°, 68°, 77°, and 86° F., respectively.

The plants were examined daily and any newly hatched larvae were removed until a time when young ceased to appear. This was considered proof that hatching was complete. By this method it was possible to determine accurately the time and rate of hatching. Table 1 summarizes the results obtained.

TABLE 1.—Developmental Period of Gladiolus Thrips Eggs at Five Levels of Temperature

Temp. °F.	Plant No.	Time required to hatch, shown in 2-day intervals														Developmental period in days		
		2	4	6	8	10	12	14	16	18	20	22	24	26	28	Min.	Max.	Mean*
50	1								2	6	10	11	10	5	0	16	25	21.11
	2								0	0	5	14	16	3	9	19	27	23.36
	3								0	0	6	26	29	13	11	19	27	23.46
Total									2	6	21	51	55	21	20	Average		22.64
59	1					3	50	66	51	0						10	16	13.41
	2					11	49	74	31	4						10	18	13.16
	3					12	26	18	2	1						10	17	11.92
Total						26	125	158	84	5						Average		12.83
68	1			95	30	3										5	10	6.03
	2			17	55	20										5	9	7.35
	3			67	125	11										5	10	6.85
Total				179	210	34										Average		6.74
77	1	7	79	1												2	5	3.20
	2	6	171	0												2	5	3.20
	3	3	78	1												2	5	3.50
Total		16	328	2												Average		3.30
86	1	26	111	0												2	4	2.82
	2	46	60	1												2	5	2.60
	3	31	99	29												2	5	3.29
Total		103	270	30												Average		2.90

*The figures in this column represent the weighted mean or the average of the incubation period based on the daily, rather than the 2-day interval, hatch.

The table shows that the average hatching periods at the various temperature levels were as follows: At 50° F., 22.64 days; 59°, 12.83 days; 68°, 6.74 days; 77°, 3.3 days; and 86°, 2.9 days. The data indicate that most of the eggs hatched at the temperature levels from 59° to 86°, inclusive; whereas at 50° many of the eggs failed to hatch. Moreover, those hatching at 50° were greatly weakened and undoubtedly there must be a high mortality at this temperature.

THE LARVA

In studying the development of the larva under storage conditions, it was found possible to return to the use of cormels instead of the growing plants employed for the study of the eggs.

Each newly hatched larva was placed in an individual shell-glass vial which contained a bottom layer of white sand moistened with water. The vial was closed with a cloth-covered cotton plug through which a pin was thrust. On the point of the pin was impaled a small husked cormel (22) to serve as food for the larva. The recently hatched larva of the gladiolus thrips is quite fragile, and, in order to avoid injury, all transfers of the insects to the previously prepared vials were made by means of a camel's hair brush dipped in distilled water.

Altogether, more than 300 vials were prepared in the manner described, and these were divided into five lots in which there were at least 60 vials each. The lots were then placed in the series of constant temperature cabinets where the same temperature levels were maintained as those used in the study of the egg stage. Ordinarily, all the vials were examined daily to determine the progress the insects were making but in some instances more frequent examinations were made.

In Table 2 is shown the condensed record of the behavior of both the first and second instar larvae at the five levels of temperature employed.

TABLE 2.—Developmental Period of Gladiolus Thrips Larvae at Five Levels of Temperature

Temperature	Larvae*		Days required to complete first and second instars					
	First instar	Second instar	First instar		Second instar		Average	
			Min.	Max.	Min.	Max.	First instar	Second instar
50	6	....	10	24	....	....	18.33	....
59	34	11	5	11	7	16	7.91	11.18
68	43	20	3	5	4	7	3.44	5.70
77	34	29	1	3	2	3	2.06	2.52
86	47	29	1	2	2	3	1.77	2.35

*When this insect passes from one stage to another, it sheds its skin at each transformation. The only index that a first instar larva had completed this stage was the cast skin. The cast skin dries rapidly to the size of a fine thread; hence, it was likely to escape observation and in many cases it could not be found. Therefore, only those cases where the cast skins were found are included in the table, although many others successfully completed the transformation, especially in the more favorable temperature levels. The index of the termination of the second instar larval period was the emergence of the first pupal instar with the short wing-pads. Consequently, it was not necessary to locate the cast skins for this stage, although they were observed in many instances. These figures refer to the total number of each of the original lots of 60 or more insects, which were actually observed to complete the first and second instar developmental periods at the different temperature levels used.

A study of Table 2 shows that at a temperature of 50° F. mortality was very high among the first instar larvae and that none was able to develop to the second instar. At 59° and at 68° F., some survived to the second instar but the lots placed in temperatures of 77° and 86° F. experienced a lessened amount of difficulty in surviving to and completing the second instar. More than 60 insects were in the original lot placed in the 77° F. cabinet, which accounts for the larger number shown to have transformed to the second instar.

It should be noted also, as shown by the last two columns of the table, that at the higher temperatures larval development was rapid whereas a much longer time was required at lower temperatures for the insects to reach larval maturity.

THE PUPA

In the study of pupal development, the same levels of temperature were maintained in the cabinets as in the larval studies and the individual insects were confined in vials containing an impaled cormel. Moreover, the pupae in each cabinet were developed from larvae which had been reared at that particular temperature. It will be noted that no pupal developmental studies were conducted in the 50° F. cabinet, because no larvae reached the pupal stage at that temperature. Daily examinations were made to note the progress of the insects.

The index for the termination of the first pupal instar was the appearance of the long wing-pads characteristic of the second pupal stage, and the appearance of the adults indicated the end of the second pupal stage.

The developmental periods of the pupal instars are shown in Table 3.

TABLE 3.—Developmental Period of Gladiolus Thrips Pupae at Five Levels of Temperature

Temperature	No. observed		Days required to complete first and second instars					
			First instar		Second instar		Average	
	First instar	Second instar	Min.	Max.	Min.	Max.	First instar	Second instar
50	0	0	0	0	0	0	0	0
59	15	9	3	9	5	9	5.00	7.56
68	30	27	1	6	4	10	2.70	5.15
77	67	62	1	2	1	4	1.85	2.52
86	31	19	1	3	1	3	1.51	2.16

In this table it can be seen that the second pupal period is considerably longer than the first and that the time required to complete pupal transformations was considerably longer in the colder than in the warmer cabinets.

SUMMARY OF LIFE HISTORY IN STORAGE

Table 4 shows a comparison of the developmental periods of the various stages of the gladiolus thrips at five levels of temperature under storage conditions.

The data presented in Table 4 show that the most rapid development of this insect occurs at the temperature of 86° F. This is true for all the immature stages—egg, larva, and pupa. However, since the number of insects successfully reared to adulthood is considerably smaller at 86° and 68° F. than at 77° F., it is evident that the optimum temperature for the development of the gladiolus thrips under the conditions of this experiment is somewhere around 77° F. It may be mentioned also that Smith and Nelson (22) found that the optimum development of this thrips occurred at about 80° F.

TABLE 4.—Developmental Period of All Stages of Gladiolus Thrips in Storage at Five Levels of Temperature

Stage of insect	Temperature °F.	Individuals observed	Period of development, in days		
			Minimum	Maximum	Average
Egg	50	176	16	27	22.64
	59	398	10	18	12.83
	68	423	5	10	6.74
	77	346	2	5	3.30
	86	403	2	5	2.90
Larva	50	....	....	....	....
	59	19	12	27	18.58
	68	36	7	12	9.17
	77	70	3	6	4.51
	86	47	3	5	3.94
Pupa	50	....	....	....	....
	59	9	8	18	11.67
	68	25	2	12	7.44
	77	62	2	6	3.85
	86	19	2	6	3.47
Total time from egg to adult	50	....	....	....	....
	59	....	30	63	42.74
	68	....	14	34	23.39
	77	....	7	17	11.66
	86	....	7	16	10.29

A further study of this table shows that it was impossible to rear a generation through at 50° F., that all the immature stages were completed at 59°, 68°, 77°, and 86° F., and that, in general, development was accelerated with increasing temperature. The time required for total development, as shown in the lower part of the table, was calculated from the combined length of the different stages. It can be seen that the average periods of development at 59°, 68°, 77°, and 86° F. were 40.95, 23.69, 11.68, and 10.26 days, respectively.

The conclusions drawn with respect to the data presented in Table 4 are further substantiated by information gained from infesting clean gladiolus corms with adult thrips and placing the several lots in each of the five constant temperature cabinets previously referred to. No development occurred at the lowest temperature, but reproduction of insects and damage to corms were profuse at the higher temperature levels.

NUMBER OF GENERATIONS

In this investigation, the actual number of generations was not determined under the conditions of storage studied. However, this can be calculated with a fair degree of accuracy for any temperature and time by referring to the data given in Table 4. The important consideration to bear in mind is that within reasonable temperature limits, the warmer the storage the greater will be the number of generations produced and, consequently, the more severe the damage inflicted to the corms in storage; this, in turn, is reflected in damaged flowers and corms the following season. This point is of great practical importance to the grower.

DEVELOPMENT ON LIVING PLANTS

No extensive records were taken on the development of the various stages of the gladiolus thrips under field conditions. However, during August, 1931, some records were taken relative to the incubation of the eggs and the total developmental period from egg to adult. These data were obtained by confining the thrips in small shell vials with sections of gladiolus leaves as food. The leaf sections were kept turgid with moist, white sand in the bottom of the vials. Fresh food was supplied when needed. The data obtained in this manner are shown in Table 5.

TABLE 5.—Incubation Period of Gladiolus Thrips Eggs and Total Developmental Period for All Stages

Stage of insect	No. insects observed	Temperature °F.			Humidity % relative			Period of development, in days		
		Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
Egg	102	78	87	84	49	60	55	1	4	2.94
Egg to adult	216	....	....	73	....	....	59	9	17	13.55

The temperature and humidity during these experiments were quite favorable for thrips development. The average incubation period was 2.94 days, and the total developmental period was 13.55 days. These records compare quite favorably with the rate of development of the thrips on corms in storage when somewhat similar temperatures were maintained.

During the season of 1932, Smith and Nelson (22) conducted some extensive studies concerning this phase of the insect's life history. They found that the average period of development for the various stages of the gladiolus thrips was as follows: Egg development, 4.66 days; larval development, 3.78 days; pupal development, 6.61 days; and egg to adult, 15.5 days.

During the period of June 10 to October 15, 1932, nine complete generations were reared in the insectary at Wooster, Ohio. This is an average of one generation every 2 weeks. Since some growers start their gladiolus plantings early in April, it is possible that several generations, in addition to the nine recorded in this investigation, might develop normally during the course of the growing season.

General field observations, together with the detailed life history studies, indicate that this pest thrives best under hot, dry, weather conditions. Cool, rainy weather, on the other hand, retards its development considerably. A heavy dashing rain may reduce the population as much as 50 per cent. This was demonstrated in 1933 when counts were taken on heavily infested gladiolus plants just before and after a heavy, dashing rain. The results of these counts are given in Table 6.

This table shows, as might be expected, that the greatest reduction occurred to those insects located on the outside of the plant. The total insect reduction on the outside of the plant was 87 per cent as compared to 22 per cent on the inside. In considering the total population on the plants, more adults than larvae were destroyed by the storm, and the total insect reduction was 50 per cent.

TABLE 6.—Effect of a Heavy Dashing Rain on Thrips Populations

Stage of insect	Outside of plant*			Inside of plant*			Outside and inside of plant		
	Before rain	After rain	% reduction	Before rain	After rain	% reduction	Before rain	After rain	% reduction
Adults	217	36	83	192	106	45	409	142	63
Larvae	489	59	88	719	600	17	1208	659	45
Adults and larvae	706	95	87	911	708	22	1617	803	50

*In recording these data, each plant was examined under a binocular microscope. The insects observed on the exposed surfaces of the plant were designated as "outside of plant". Those insects found behind the leaf sheaths and in the enclosed area peculiar to the leaf of the gladiolus were distinguished as "inside of plant".

The data just presented concerning the effect of a dashing rain on gladiolus thrips population have some practical value as a suggested control for the use of the home gardener. Several severe syringings of the plants with a garden hose would aid materially in reducing the thrips population. Such a plan would be practicable for small areas only.

NATURAL ENEMIES

During the course of this investigation, only one species of insect, (*Triphleps*) *Orius insidiosus* (Say), was observed to feed upon the gladiolus thrips. This is a small, native bug not very much longer than the adult female thrips. It is not a significant factor in thrips control.

HABITS AND MIGRATION

The secretive habit of the gladiolus thrips was noted, especially in the detailed life history studies and in the extensive population counts which were made both in the field and in the greenhouse. This habit was more marked in the larval than the adult stage. When the percentage of insects located on the inside and outside of the plants was calculated from the data presented in Table 6, it was found that 56 per cent was taken on the inside of the plant as compared to 44 per cent on the outside.

In some instances, the adults showed a positive reaction to light; however, no special effort was made to prove this definitely. On gladiolus plants grown in the greenhouse, both larvae and adults thickly populated the outside of the foliage, but in the field the adults were seen more commonly than the larvae as one walked through the plantings. When heavy infestations prevailed in the field, however, the larvae were also found feeding on the leaf surfaces, apparently because of the exhaustion of food supply in the more tender parts of the leaf sheaths.

The larvae were observed to feed quietly close beside one another in heavily populated leaf sheaths. The pupae were usually found at the upper extremity of the sheaths or in other isolated places on the plant where they would be undisturbed, as for example among the petals of the flowers. Under greenhouse conditions, a few insects were observed to pupate in the soil, but it is believed that this is not normal under field conditions.

The gladiolus thrips is quite sluggish in comparison with other species, such as the onion thrips, *Thrips tabaci* Lind., and the flower thrips, *Frankliniella fusca* Hinds. Because of this, ordinarily very little migration occurs in the field prior to the blooming period. This fact may account for the error many growers make in judging varieties for susceptibility or resistance to thrips attack; for example, one of two adjoining varieties may be heavily infested and the other comparatively free, whereupon the grower decides the one is susceptible and the other resistant. The truth of the matter may be that both are equally susceptible. The one showing heavy infestation may have been grown from infested corms and the other from corms free from infestation, but, because of the sluggishness of the insects, the infestation of the two varieties has not been equalized. Unquestionably, however, some varieties are more susceptible to thrips than others. This will be pointed out later under the discussion of varietal resistance.

Considerable migration occurs, particularly when plants become so heavily infested that the exhaustion of the food supply compels the insects to seek other plants. This was definitely observed in some of the untreated plots in the insecticide tests in the field and was demonstrated also in the following greenhouse experiment. The entire space of a 22 x 28 - foot greenhouse room was planted to gladioli arranged in narrow plots containing 40 plants each. The planting originally had been used for insecticide tests, in the execution of which several check or untreated plots were located in different sections. These became heavily infested with thrips.

In order to determine whether the thrips migrated from these heavily infested plots, sheets of tanglefoot 8 inches square were erected on standards a little above the tops of the plants and were located one on each side of each check plot. The sheets were examined at four intervals from 5 to 7 days apart and the trapped insects recorded and removed. A total of 732 insects was captured in this manner, thus indicating that there was considerable flight movement in the house and that beyond doubt the insects migrate from one plant to another. It has never been determined, however, the maximum distance the insect is able to travel. The fragile nature of the insects would indicate, however, that unless the conditions were very unusual, the distance probably is limited to a few hundred feet at most.

HOSTS

Although the gladiolus thrips is primarily a pest of gladioli, natural infestations have been noted by the writer on Japanese and German Iris, Calla Lily, and Torch Lily or Poker Plant (*Kniphofia*). In addition, Weigel, Smith, and Richardson (25) have found this pest breeding on Montbretia (*Tritonia*) and Tigerflower (*Tigrida pavonia*).

The writer has also collected adults from plantain, aster, clover, calendula, goldenrod, mullein, and Coreopsis. All of these plants were growing near heavily infested plantings or discarded piles of infested flower spikes. Since breeding was not observed on these plants, it is assumed that the thrips were feeding on them only temporarily. This was true also of the adults collected by Weigel, Smith, and Richardson (25) on the flowers of Buddleia, Dianthus, and Lathyrus. In the greenhouse, adults were taken by the writer on tomato, begonia, and chrysanthemum foliage and on the flowers of geranium, primula, begonia, and snapdragon.

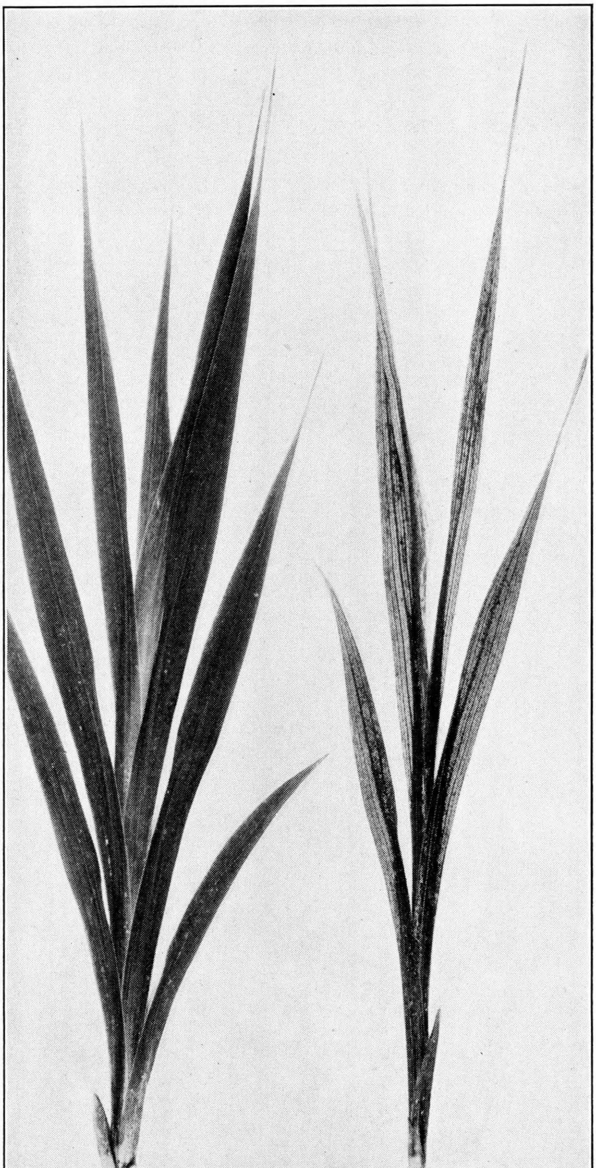


Fig. 4.—Gladiolus plant at right severely injured by thrips. Plant at left, normal

INJURY TO FOLIAGE AND FLOWERS IN THE FIELD

Like other species of thrips on other plants, both adults and larvae of the gladiolus thrips feed by rasping and puncturing the surface cells of the leaves and then lapping up the exuding plant juices. The green chlorophyll from the leaves can readily be seen through the body wall of the larvae. Because of the injury to large areas of adjacent cells, gladiolus foliage under heavy infestation conditions is characterized by a silvering or blasting of the leaves as shown in Figures 4 and 5. At the outset, many growers attributed this abnormal appearance of their plantings to drouth conditions.

Examinations of leaf sheaths of infested plantings usually reveal the presence of large numbers of larvae and adults. Because of the voracious feeding of the larvae, the tissues of the leaf sheaths soon turn brown and appear dead. When the flower stalk is growing out of the last bud sheath, it is attacked in the same way. Such injured stalks usually are more brittle and, consequently, break over easily.

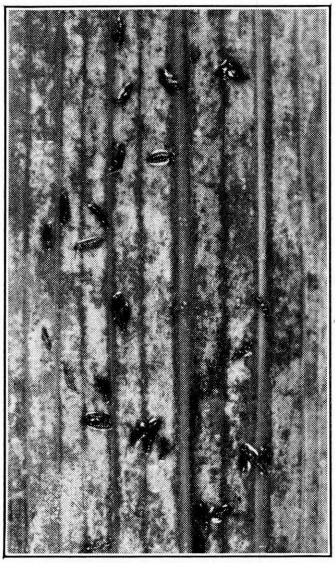


Fig. 5.—Leaf section showing adult thrips and injury to leaf surface. (magnified 2.5 x).

When the flower spike appears, the leaves are forced apart somewhat and the insect readily gains entrance to the leaf sheaths. Moreover, the spike furnishes fresh, tender food, and, as a composite result of all these factors, the rate of reproduction seems to increase appreciably. The injury to the flowers is perhaps the most important and, therefore, the symptom most frequently observed by the grower. If the infestation is heavy, the flowers will be either seriously deformed (Fig. 6) or they may fail to bloom. Even under conditions of light infestation, the insects remove some of the coloring matter from the petals, and this is responsible for the flecked appearance of the flowers, which

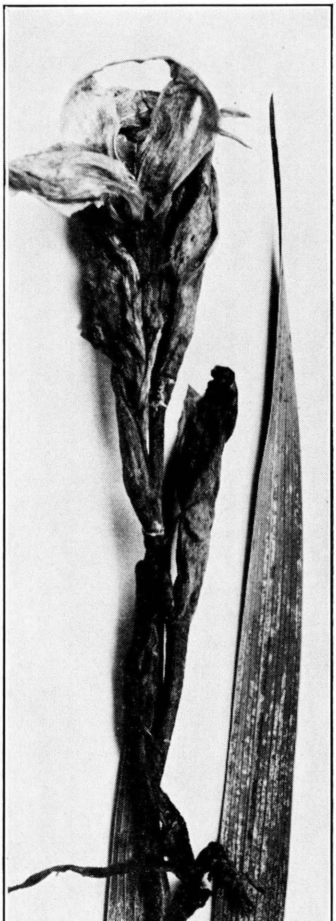


Fig. 6.—Flower spike severely damaged by gladiolus thrips

detracts from their sale value. This type of injury is more conspicuous on dark red and purple flowers than on the white or pale-colored ones. The greater part of the injury to the flowers, however, results from the feeding which occurs before they open. This fact makes it very difficult to effect any degree of control after the plants start to spike.

VARIETAL RESISTANCE

During the summer of 1931, it was noted that some varieties produced good flowers even though the flowers of others grown near by were completely ruined by the thrips. Some of the growers also observed this occurrence, and several of them immediately began advertising certain of their corms as "thrips-resistant varieties".

For this reason, in the spring of 1932, a varietal test experiment was laid out at Ravenna, which is located in an important gladiolus section of Ohio. Growers contributed about 10,000 corms for these tests. In selecting the varieties, early, medium, and late flowering sorts were chosen.

On May 16, 2 days previous to the time of planting, all the corms were dipped in bichloride of mercury. This was necessary because the stocks had been obtained from several sources, and thus it was probable that the corms varied considerably in degree of infestation. By dipping the corms before planting, each variety was given an equal standing with every other variety.

A series of plots, each four rows wide with 50 corms to the row, was arranged at random and replicated four times. A space of 2 feet separated the plots in an east and west direction, and a vacant row separated them the other way.

All the corms sprouted well and a good, uniform stand was obtained. In June, a light thrips infestation was noted in the plots, which increased considerably during July. Records consisting of the total number of expanded florets showing thrips injury were started early in August when the first variety began blooming, and these were continued twice a week until the latter part of September, when the last variety had finished blooming. A summary of the data which were taken on the infestation and blooming date of the flowers is shown in Table 7.

TABLE 7.—Percentage of Florets Injured and Number of Days to Blooming for 12 Varieties of Gladiolus, 1932

Varieties	Section A Per cent injured florets					Section B Number of days to blooming				
	Replications					Replications				
	1	2	3	4	Mean	1	2	3	4	Mean
Elizabeth Tabor	37	24	45	28	34	92	90	87	88	89
Sheila	14	22	20	32	22	89	89	91	88	89
Dr. Van Fleet	1	5	2	3	3	84	85	83	82	84
Crimson Glow	37	27	50	44	40	95	97	98	96	97
Purple Glory	72	98	85	94	87	106	101	102	99	102
America	17	14	3	21	14	104	98	100	104	102
Los Angeles	59	71	76	75	70	109	105	106	103	106
Evyln Kirtland	38	39	44	72	48	109	104	105	104	106
Herada	40	39	35	77	48	110	112	111	108	110
Giant Nymph	39	12	4	16	18	112	114	110	113	112
Mrs. Frank Pendleton	27	16	25	64	33	113	119	113	112	114
Scarlet Wonder	99	70	95	84	87	123	124	134	124	126

In Section A of Table 7 it may be seen that there was a wide variation in the percentage of damaged flowers in the different varieties. The damage varied from 3 per cent in Dr. Van Fleet to 87 per cent in Scarlet Wonder and Purple Glory. The varieties America and Giant Nymph had a comparatively low degree of damage, 14 and 18 per cent, respectively; whereas Los Angeles suffered rather severe damage, 70 per cent.

In Section B, which shows the average blooming date, it may be seen also that there was a wide variation in the time of blooming. It was found that a significant correlation (7) existed between the blooming date and the percentage of damage to the flowers. In general, the late-blooming varieties were damaged more than those that bloomed early. In this particular experiment, each increase of 1 day in "Days to blooming" caused, on the average, an increase of nearly 1.3 per cent in infestation.

Further study of the relationship between degree of damage and blooming shows, however, that there are exceptions to this tendency; for example, Giant Nymph and Mrs. Frank Pendelton are late-blooming varieties, but they were slightly damaged. On the other hand, Crimson Glow and Purple Glory are relatively early-blooming types but they were seriously injured. Inasmuch as the number of days to blooming and actual infestation of the 12 varieties were known, it was possible to calculate (6) the estimated infestation based on the number of days to blooming. When these data were compared with the actual infestation of each variety, the degree of resistance or susceptibility was demonstrated.

In Table 8 the varieties are arranged in the descending order of resistance to susceptibility.

TABLE 8.—Resistance and Susceptibility of Gladiolus Varieties

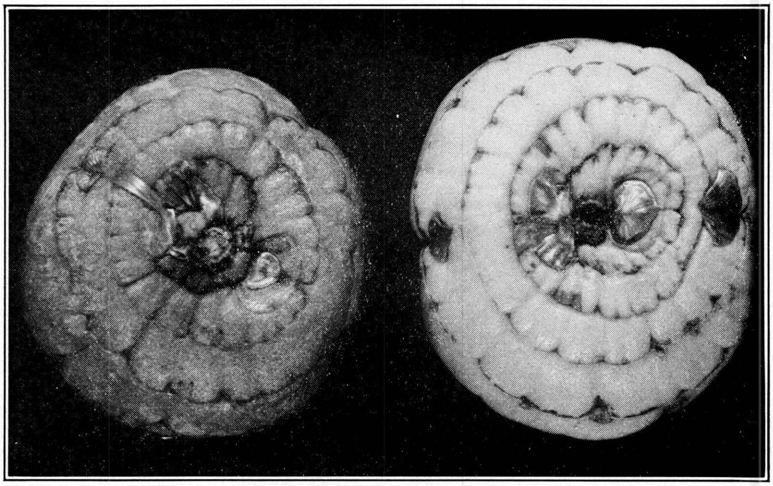
Variety	Rating	Variety	Rating
Giant Nymph	Resistant	Evyln Kirtland	
America	Resistant	Crimson Glow	
Mrs. Frank Pendelton	Resistant	Elizabeth Tabor	
Dr. Van Fleet		Scarlet Wonder	
Herada		Los Angeles	Susceptible
Sheila		Purple Glory	Susceptible

Giant Nymph, America, and Mrs. Frank Pendelton are clearly resistant, and Los Angeles and Purple Glory are susceptible. The remaining seven varieties are neither resistant nor susceptible to a significant degree.

In presenting these varietal studies, the writer is aware that the evaluation of only 12 among the many thousands of gladiolus varieties constitutes but a meager start. Nevertheless, this experiment clearly indicates the possibility of the control of this pest by the cultivation and development of resistant varieties

INJURY TO CORMS IN STORAGE

Stored corms infested with the gladiolus thrips soon become sticky from the bleeding of the injured cells. Fortunately, however, both the juices and epidermal cells harden or suberize; thus, the corm is protected but its sale value is decreased because of its roughened texture and darkened color (Figs. 7a and 7b).



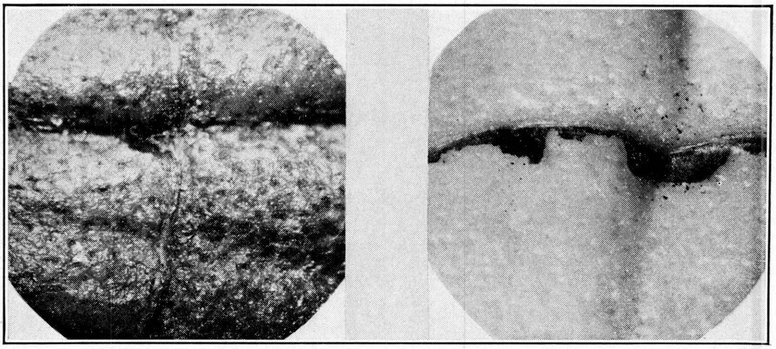


Fig. 7.—*Upper*—Gladiolus corm at left severely injured by thrips. Corm at right, normal. *Lower*—Magnified sections of above corms, showing rough and smooth surfaces

When excessive feeding occurs around the base of the corms, many of the cells which form the young roots are injured. As a result of this injury, the growth of the root system is retarded or impaired to such an extent that many corms produce small deformed flowers or the plants die before blooming. Many examples of this were observed, especially among the heavily infested corms which were used in the insecticide tests.

Another common place of thrips feeding on the corms is around the eyes or developing bud shoots. In many cases, the buds are killed and the corms fail to germinate. When the serious damage which may occur to corms in storage is considered, the necessity for adequate preventative or control measures is apparent. A fortunate aspect of the situation is that the stored cormels are immune from attack. It appears that the shell or covering is so hard that it offers no opportunity for surface feeding. Moreover, the cover fits so tightly that the insects cannot reach the softer tissues beneath.

CONTROL

In working out control measures for the gladiolus thrips, preventative or indirect control measures, such as methods of harvesting and proper methods of storage, were considered, as well as the treatments which were applied directly to the corms in storage and to the growing plants in the field.

INDIRECT CONTROL

METHODS OF HARVESTING

In heavily infested plantings, the method which the grower uses in harvesting determines largely the number of thrips which follow the corms into the storage. When the tops are cut or broken off, some insects are shaken from the infested foliage. If the topping is done directly over the container in which the corms are collected, infestation is certain to take place. On the other hand, freshly dug corms which had been properly handled were never found infested, although many examinations were made.

When lifted corms were allowed to remain in the field among the infested tops for a week or two, they became heavily infested. The infestation was found to be higher on those corms scattered loosely on the ground than in others placed in sacks. Apparently, the sacks checked the movement of the thrips.

From the facts presented in the preceding paragraphs, the importance of removing the corms from the field as quickly as possible after they are lifted and then allowing them to cure at a considerable distance from the plantings is not to be overlooked. The home gardener may even find it profitable to cut and dispose of the infested tops before the corms are lifted. This is not advocated for the commercial grower, however, because of the extra time and labor involved.

Another harvesting procedure which should be mentioned is the manner of removing the tops from the corms. It has been found that, when the tops are removed with pruning shears, the husks are left intact, thus hampering the entrance of the thrips to the corm beneath the husks. On the other hand, when the tops are jerked off, the husks are opened and chances of infestation are greatly increased. Moreover, some of the larger growers seem to be agreed that cutting the tops is a more efficient method of removal.

PROPER METHODS OF STORAGE

In a previous section of this publication, in the discussion on "Development in Storage", pages 9-13, it was pointed out that no reproduction occurred at 50° F. but that with an increase in temperature there was an acceleration in the rate. Many of the larger growers have proper facilities and can maintain a low storage temperature; on the other hand, the home gardener, in most cases, utilizes his basement cellar for this purpose. Many examinations of corms stored under such conditions show that considerable reproduction occurs, especially where the corms are near the furnace or hot water pipes. Such sources of high population will tend to contaminate all the corms further because there is considerable migration within the storage.

In order to help the home gardener and small grower in the solution of his storage problem, two storage methods for the corms were tried at the Experiment Station during the winter of 1932-1933. A room 10 x 10 feet, with composition board walls, was constructed in a basement. The temperature in the room was regulated by means of an outside window, which was opened or closed, depending on outside weather conditions. A very desirable storage humidity was maintained with the use of moistened sand on the floor. Most of the corms used in the experimental work with this insect were kept in this storage.

The other type of storage which may be used for small lots of corms is shown in Figure 8. It consisted of vitrified sewer tile 20 inches in diameter set 24 inches in the earth and with about 4 inches extending above the soil level to exclude surface water. A site was chosen on a gently sloping hillside to facilitate drainage. A slatted platform was installed 2 inches above the bottom of the pit and a wooden cover closed the top. Three inches of sawdust and a mound of leaves were placed on top of the wooden cover, and the whole was covered with waterproof tar paper to exclude rains. Two such structures were installed. In one was placed paper bags containing heavily infested corms which had not been treated and, in the other, corms, infested to a similar degree, which had been fumigated. The corms were stored December 5, 1932, and, with the one exception when the pits were opened December 19 for sampling the two lots to determine the initial effect on the treated lot, the pits were not disturbed until the following spring. The influence of the treatment on the infestation of thrips on the corms will not be included here but will be discussed on pages 30 and 31.

Fig. 8.—Tile storage pits for corms. Above, closed. Below, open

A continuous temperature record was kept during the winter by means of a recording thermograph. At no time did the temperature drop below freezing but remained rather constant at about 40° F. Although the humidity was not recorded, unquestionably it was high.

When the pits were opened and the corms examined the following spring (March 8), those from both chambers were found to be in excellent condition. They were as plump and fresh as at the time they were placed in storage. Moreover, no living insects could be found on either lot. The assumption is that the combined low temperature and relatively high humidity of the chambers killed the insects. This conclusion seems to be a safe deduction when it is recalled that the combination of high temperature and low humidity favors thrips multiplication during the storage season.

In Figure 9, two corms from the tile chamber are compared with two from the basement storage. It can be seen that the corms that had been in the tile chamber were plump and fresh; whereas those from the basement storage were slightly shrunken and suberized. When a large but equal number of corms from each type of storage were weighed, it was found that those from the basement storage were considerably lighter. When some corms from both types of storage were planted and subsequent growth of the foliage, flower spike, and corm yield were measured, no significant differences in these respects were noted.

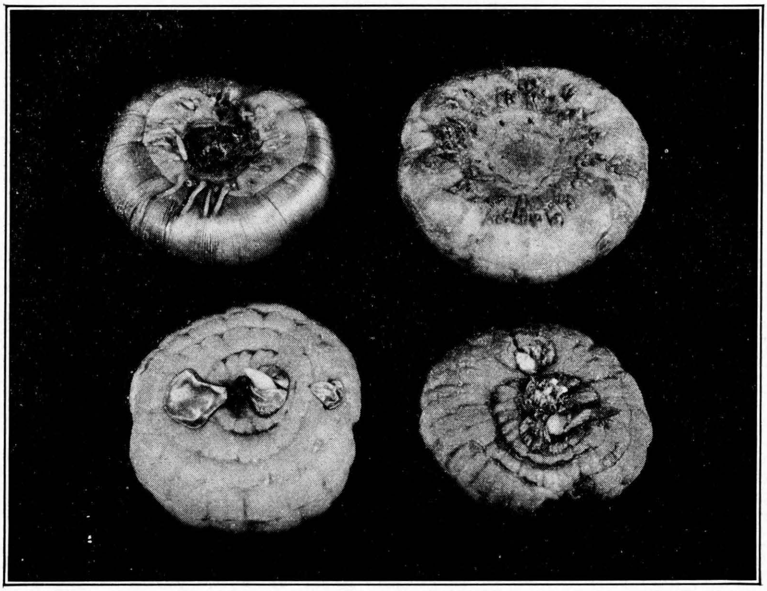


Fig. 9.—Gladiolus corms at left from outdoor pit storage; at right, from basement storage. Note superior condition of former

The foregoing storages are suggested as an aid to the solution of the storage problem. The pit type of storage has been discussed in some detail because it is felt it may offer a solution of the storage problem for the small grower who has only the basement of his dwelling in which to keep his corms. A barrel or box with the bottom removed or perforated to admit soil moisture probably would serve equally as well as the tile employed in this test.

Even with the best usage of harvesting methods and storage facilities some thrips infestation may occur. Therefore, it seems important that an adequate treatment be given the corms either before they are placed in storage or in the spring before planting.

CONTROL IN STORAGE

Inasmuch as the gladiolus thrips, under Ohio conditions, hibernates almost entirely, if not exclusively, on corms in storage, the most important source of field infestation will be removed if an effective control measure is applied to the corms before planting. Because of the importance of this phase of the problem, an extensive search was made to find adequate measures for destroying the insects on stored corms. Most of this work was done during the winter and spring months of 1931 and 1932. The discussion to follow will deal with the methods used in testing the various materials and the results obtained.

The treatments for the corms in storage have been placed in three major groups according to the action and nature of the material. These are (a) quick-acting fumigants, (b) slow-acting fumigants, and (c) insecticidal dips.

Corms of the 1910 Rose variety were used throughout these tests. The corms were cured and the old ones removed. The new corms were not husked because it is considered impractical, except for the small grower, to do this before treatment. Several days before fumigation the corms were artificially infested, either by placing among them other corms which bore a heavy population of the insects or by introducing the insects directly on the corms. Thus, all stages of thrips were present at the time the work was done.

QUICK-ACTING FUMIGANTS

The tests with these fumigants were made in a 43-cubic foot fumigation box at a minimum temperature of 70° F. In the preliminary experiments to determine the rapidity of the action of the fumigants, some insects were collected in vials and exposed to the gas in the fumigation box. The end of each vial was covered tightly with muslin held in position by a rubber band. Most of the tests, however, were made by placing infested corms in muslin bags, after which the bags were buried among other corms in the fumigation box in order to simulate normal storage conditions. When the records were taken, all the insects were counted with the aid of a low-powered binocular.

The quick-acting fumigants tested were as follows:

(a) Ethylene dichloride (3 parts), carbon tetrachloride (1 part).

(b) Ethylene dichloride (2 parts), carbon tetrachloride (2 parts).

(c) Calcium cyanide (crude) A-Dust (not less than 40% and no more than 50% active ingredient).

Because fumigants a and b have rather long names, they will be referred to hereafter as Mixture (3 to 1) and Mixture (2 to 2), respectively. These materials in a 3 to 1 ratio were first used on gladiolus corms by Dustan (4). The results of the preliminary tests are shown in Table 9.

TABLE 9.—Preliminary Fumigation Tests on Adult Thrips in Vials

Treatment	No. tests	Duration of treatment	No. insects Dead	No. insects Alive	Per cent mortality
		Hours			
Ethylene dichloride (3 parts) Carbon tetrachloride (1 part) 14 lb.-1000 cu. ft.	1	1	24	3	89
	3	2	82	4	95
	2	3⅔	60	0	100
	1	5	26	0	100
	2	5⅝	60	0	100
Check (No treatment)	2	1 & 5⅔	9	120	7
Ethylene dichloride (2 parts) Carbon tetrachloride (2 parts) 14 lb.-1000 cu. ft.	1	½	4	29	12
	1	1	4	15	21
	1	1½	7	12	37
	2	10	62	0	100
Check (No treatment)	2	10	8	92	8
Calcium cyanide* ¼ oz.-1000 cu. ft.	1	1½	23	7	77
	1	2½	29	0	100
	1	3½	29	0	100
Calcium cyanide ½ oz.-1000 cu ft.	1	1	28	0	100
	1	2	25	0	100
	1	4½	24	0	100
Calcium cyanide ¾ oz.-1000 cu. ft.	1	1	30	0	100
	2	2	70	0	100
	1	3	27	0	100
	1	4	29	0	100
Calcium cyanide 1 oz.-1000 cu. ft.	1	½	35	0	100
	1	1½	31	0	100
	1	2½	27	0	100
	1	3½	33	0	100
	1	6	41	0	100
Check (No treatment)	6	½ & 6	18	316	5

*(Crude) A-Dust. (Not less than 40% and no more than 50% active ingredient).

This table shows that the Mixture (3 to 1), at a concentration of 14 pounds to 1000 cubic feet, produced 100 per cent kill in 3⅔ hours, but at the end of 1 hour's exposure only 89 per cent of the insects was destroyed. Mixture (2 to 2), used at the same concentration, at the end of an hour's exposure killed only 21 per cent of the insects, thus indicating that when the materials are combined in this ratio the action is slower. Mixture (2 to 2) killed all the insects when exposed for a 10-hour period.

Calcium cyanide, when used at the rate of 1 ounce to 1000 cubic feet and at ¼ ounce to 1000 cubic feet, required ½ hour and 2½ hours, respectively, to kill all the living insects. It is evident, therefore, that this material acts more quickly than either of the combinations of ethylene dichloride and carbon tetrachloride used in this test.

The mortality in the checks for all treatments varied from 5 to 8 per cent, with an average of 7 per cent.

The results of tests in which infested corms were enclosed in muslin bags and exposed to the effects of gas are shown in Table 10.

In this table it may be seen that all the treatments gave a high kill and that the mortality in all the checks was comparatively low.

Table 11 shows a three-fold replicated series of tests in which the bags of infested corms were buried near the bottom of a bushel basket of corms.

TABLE 10.—Quick-acting Fumigants for Infested Corms

Treatment	No. tests	No. corms	Duration of treatment	No. insects		Per cent mortality
				Dead	Alive	
			Hours			
Ethylene dichloride (3 parts), Carbon tetrachloride (1 part), 14 lb.-1000 cu. ft.	5	35	24	149	1	99
Check (No treatment)	4	21	24	21	134	14
Ethylene dichloride (2 parts), Carbon tetrachloride (2 parts), 14 lb.-1000 cu. ft.	2	20	24	69	0	100
Check (No treatment)	2	20	24	5	58	8
Calcium cyanide (¼ oz.-1000 cu. ft.).......	1	5	24	39	0	100
Check (No treatment)	1	5	24	12	58	17
Calcium cyanide (½ oz.-1000 cu. ft.).......	1	5	24	25	0	100
Check (No treatment)	1	5	24	2	24	8
Calcium cyanide (¾ oz.-1000 cu. ft.)......	1	5	24	17	0	100
Check (No treatment)	1	5	24	1	30	3
Calcium cyanide (1 oz.-1000 cu. ft.)	2	10	24	37	1	97
Check (No treatment)	2	10	24	5	61	8

Table 11 shows a three-fold replicated series of tests in which the bags of infested corms were buried near the bottom of a bushel basket of corms.

TABLE 11.—Quick-acting Fumigants for Infested Corms*

Duration of treatment—24 hours

Treatment	Replications									Mean mortality
	1			2			3			
	No. insects		% mort.	No. insects		% mort.	No. insects		% mort.	
	Dead	Alive		Dead	Alive		Dead	Alive		
Ethylene dichloride (3 parts) Carbon tetrachloride (1 part) 14 lb.-1000 cu. ft.	49	0	100	77	0	100	60	0	100	100
Ethylene dichloride (2 parts) Carbon tetrathloride (2 parts) 14 lb.-1000 cu. ft.	40	0	100	48	0	100	44	0	100	100
Calcium cyanide 1 oz.-1000 cu. ft.	60	18	77	38	12	76	51	11	82	78
Check (No treatment)	0	48	0	2	44	4	5	224	2	2

*Four corms were examined in each replication, except in the last replicate of the check and in all replicates of the Cyanogas treatment where 5 corms were used.

This table shows that both mixtures of ethylene dichloride – carbon tetrachloride produced 100 per cent mortality; whereas the average mortality for calcium cyanide was only 78 per cent. Inasmuch as there was no fan to help distribute the gas in the fumigation box, it is thought that the calcium cyanide gas, which is lighter than air, had a tendency to rise rather than penetrate to the bottom of the basket of corms in which the test corms were buried. This probably accounts for the poor kill obtained. Those growers, therefore, who use this treatment should provide a fan in the storage in order to insure the proper distribution of the gas.

In the following experiment, which was performed to determine the effect of fumigation on the eggs of the gladiolus thrips, lots of five corms were placed in each of several muslin bags and 100 adult thrips liberated therein. After allowing several days to elapse for oviposition to take place, the corms were fumigated for 24 hours in all tests.

After fumigation the corms were not disturbed for about 15 days in order to permit any eggs to hatch which had not been killed by the treatments; then each corm was examined for the presence of living insects. Most of the insects that were recovered were in the larval stage, thus indicating that they had hatched from eggs which had escaped the effects of the fumigants. The results of this test are shown in Table 12.

TABLE 12.—Effect of Quick-acting Fumigants on Gladiolus Thrips Eggs

Treatment	Replicates	Period*, in days	Number adults used	No. living insects observed
Test No. 1				
Ethylene dichloride (3 parts)				
Carbon tetrachloride (1 part)				
14 lb. per 1000 cu. ft.	3	12	300	0
21 lb. per 1000 cu. ft.	3	12	300	0
28 lb. per 1000 cu. ft.	3	15	300	0
42 lb. per 1000 cu. ft.	3	15	300	2
Check (No treatment)	4	12–15	400	113
Test No. 2				
Calcium cyanide				
2 oz. per 1000 cu. ft.	3	14	300	64
4 oz. per 1000 cu. ft.	3	14	300	10
6 oz. per 1000 cu. ft.	3	15	300	6
Check (No treatment)	3	14–15	300	56

*"Period" is lapse of time between treatment and observations.

It is apparent from this table that it is possible to kill almost 100 per cent of the eggs with one treatment of the Mixture (3 to 1). The high kills which are indicated in Tables 10 and 11 also tend to bear out this statement. On the other hand, calcium cyanide does not kill the eggs, and, consequently, a second fumigation properly timed is necessary for effective control. The timing of the second treatment can be determined by referring to Table 4, which shows the period of development of the eggs at different temperatures. It is obvious, of course, that a temperature record of the storage must be kept. It is likewise important that the second treatment should be made when all the eggs have hatched and before any insects have reached the adult stage. To delay this treatment for too long a period would result in the deposition of additional eggs.

SLOW-ACTING FUMIGANTS

The fumigants which were considered as slow-acting are naphthalene flakes, nicotine dust, and paradichlorobenzene (P. D. B.). The infested corms used in this series of tests were treated in paper sacks, and the number used per sack was either 10 or 15, as is indicated in the tables showing the results. After the materials were weighed, they were sprinkled over the corms and the sacks were folded at the top and fastened with paper clips.

In the first experiment, naphthalene was the only fumigant tested. Part of the corms was held at room temperature, and the remainder was placed in one of the tile chambers described on page 24, in which a temperature of about 40° F. was maintained. Thirteen days after treatment the corms held in the warm room were examined and the number of dead and living thrips noted. No living insects were found, thus indicating that the naphthalene not only had killed all adults and larvae at the time of treatment but had either destroyed any eggs which were present or any young larvae which may have hatched subsequent to the treatment. It is possible to make this statement because the eggs of the gladiolus thrips are known to hatch in about 7 days in room temperature of about 70°. No further examination of this lot of material was made.

On the following day, or 14 days after treatment, a similar record was taken on the corms stored in the tile chamber. There were no living insects found on these corms, but, during the interim between treatment and examination, the temperature had been too low to afford any of the eggs which may have escaped the effects of the treatment an opportunity to hatch. The corms from the tile chamber were transferred, therefore, to a temperature of 59° F. and, after an interval of 30 days, were re-examined. A detailed record of the entire experiment is shown in condensed form in Table 13.

TABLE 13.—Naphthalene Flakes as a Fumigant for Infested Corms

Treatment	First examination				Second examination	
	Number corms	Days of treatment	Number insects	Per cent mortality	Days from 1st exam.	Number living insects
Basement storage 70 °F.						
Naphthalene ½ oz.-100 corms..	15	13	60	100	....	....
Naphthalene ½ oz.-100 corms..	15	13	66	100	....	....
Check (No treatment)	15	13	179	31	....	....
Check (No treatment)	15	13	101	35	....	....
Tile storage 40 °F.					Storage 59 °F.	
Naphthalene ½ oz.-100 corms..	10	14	62	100	30	17
Naphthalene ½ oz.-100 corms..	10	14	64	100	30	1
Naphthalene ½ oz.-100 corms..	10	14	91	100	30	0
Naphthalene ½ oz.-100 corms..	10	14	58	100	30	17
Check (No treatment)	10	14	39	49	30	23
Check (No treatment)	10	14	41	63	30	0
Check (No treatment)	10	14	49	80	30	28
Check (No treatment)	10	14	90	56	30	0

It may be seen in the foregoing table that naphthalene is an efficient material for destroying the larvae and adult stages of the insect, even though the temperature of the storage is as low as 40°. If the temperature is sufficiently high to permit egg hatching, the young which hatch later likewise will be killed. The data further reveal that at least some of the eggs present in the cooler chamber escaped the effect of the fumigant and hatched later after the corms were transferred to a warmer temperature. It is safe to deduce, therefore, that under some conditions, at least, eggs present are not killed by the treatment; hence, the work should be done at moderately high temperatures and sufficient time allowed to elapse to obtain the full effect of the fumigant.

Because naphthalene worked so well in these experiments, it was decided to compare other materials of a similar nature with it. Accordingly, an experiment was conducted which involved four treatments and a check, each replicated four times. The different lots of corms were placed in paper bags and a temperature of 70° F. was maintained throughout the experiment. An effort was made to increase the humidity somewhat above that of normal room conditions. This was done by placing damp soil 4 inches deep in a rectangular wooden trough 4 feet wide and 20 feet long. Five open-end boxes were then inverted over the treated bags, which were slightly elevated above the soil. The temperature remained constant throughout the experiment but the humidity varied somewhat. During the first week, the relative humidity was about 70 per cent but it varied between 50 and 60 per cent during the remaining 2 weeks. Examinations of all lots were made at weekly intervals. The results are shown in Table 14.

TABLE 14.—Periodic Examination for Determining the Efficiency of Slow-acting Fumigants on Infested Corms

Treatment	Per cent thrips' mortality														
	After 1 week					After 2 weeks					After 3 weeks				
	Replications					Replications					Replications				
	1	2	3	4	Mean	1	2	3	4	Mean	1	2	3	4	Mean
Naphthalene ½ oz. to 100 corms	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Naphthalene 1 oz. to 100 corms	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Nicotine dust 2 per cent	48	92	38	92	68	100	79	100	100	95	100	100	100	100	100
P. D. B. 1 oz. to 100 corms	100	100	97	100	99	100	94	100	100	99	100	100	100	100	100
Check (No treatment)	43	70	13	23	37	40	53	54	35	45	56	83	42	41	56

The data presented in this table tend to emphasize further the efficiency of naphthalene flakes. After an exposure of 1 week, even at the low rate of ½ ounce to 100 corms, all the insects were dead. Although the efficiency of naphthalene at the two rates used in this experiment was equal, it is thought that, for the purpose of insuring control, the heavier concentration should be used in general practice. This suggestion is made because the containers for the corms used by the grower may not be as tight as the paper bags used in this experiment. In general, nicotine dust and P. D. B. required an exposure of 3 weeks in order to effect 100 per cent mortality. However, since only one living insect was found in each of the first two examinations of the corms treated with P. D. B., this indicates that it is very toxic to the insects. On the other hand, it is also quite injurious to the corms, in that it discolors the tissues and in many cases kills the young growing shoots. It seems, therefore, that this treatment is dangerous to use unless some method could be devised for preventing it from coming into direct contact with the corms. Although the corms treated with nicotine dust showed no apparent injury, the white coating of lime not only makes them unpleasant to handle but it also marred their sale value. It is obvious, therefore, that naphthalene flakes are far superior to either nicotine dust or P. D. B. as a corm treatment.

INSECTICIDAL DIPS

The various dips tested were Calogreen, calomel, mercuric chloride (corrosive sublimate), Semesan, carbon disulphide emulsion, and goulac-nicotine combination. These tests were conducted at room temperature. Infested corms were placed in small muslin bags which were dropped into 3-gallon crocks containing the dips. Some of the check corms were dipped in water; whereas others received no treatment. All of the counts were made 5 days after the treatment, but, in some cases, another count was made 1 month later in order to determine the effect on the eggs. A comparison of these tests is given in Table 15.

TABLE 15.—Insecticidal Dips for Infested Corms

Treatment	Duration of treatment	Per cent thrips' mortality			
		Replications			
		1	2	3	Mean
Calogreen, 1 lb. to 2½ gal.	5 min.	93	100	100	98
Calomel, 1 lb. to 2½ gal.	5 min.	90	88	96	91
Calogreen, 1 oz. to 1 gal.	5 min.	83	80	79	81
Calomel, 1 oz. to 1 gal.	5 min.	89	93	91	91
Check, water alone	5 min.	36	27	23	29
Carbon disulphide*, 50% miscible, 1-1000	15 min.	51	....	....	....
Mercuric chloride, 1 oz. to 7½ gal.	3 hr.	100	100	100	100
Goulac 1%-B. L. 50, 1-379	3 hr.	76	70	72	73
Check, water alone	3 hr.	44	28	38	37
Semesan, 1 oz. to 3 qt.	7 hr.	100	100	100	100
Check, water alone	7 hr.	40	46	58	48

*This mixture was emulsified by agitating together equal amounts of carbon disulphide and distilled water in which a bit of soap had been dissolved. The emulsion was used 1 part to 1000 parts of water. Three lots of corms were treated, but the record was taken on one lot only because it was found that the mortality was far too low to render this material worthy of further consideration.

In this table, Calogreen (1 pound—2½ gallons) with a treatment period of 5 minutes gave a kill of 98 per cent as compared to 91 per cent for calomel (1 pound—2½ gallons). When these two materials were weakened to 1 ounce to 1 gallon, their efficiency with the same duration of treatment was lowered, especially with Calogreen. It is possible that longer periods of treatment would have given better control but this was not demonstrated. The treatments of mercuric chloride (1 ounce—7½ gallons) and Semesan (1 ounce—3 quarts) for periods of 3 and 7 hours, respectively, gave 100 per cent mortality. The corms which were treated with Semesan, Calogreen, and calomel retained considerable amounts of the materials, and it is probable that the residual effect aids materially as a protection against reinfestation. The carbon disulphide emulsion and goulac-nicotine combination killed many of the insects, but these materials cannot be considered efficient control measures.

It might be argued that the death of the thrips was due to drowning during the 7-hour immersion period, but, when the corms were submerged in water alone for this period, only 48 per cent of the insects was killed.

The results shown in Table 16 were obtained by examining one lot of corms 5 days after treatment and a second lot 1 month later. The second examination yielded some definite information regarding the effect of these materials on the eggs.

TABLE 16.—Initial Kill and Residual Value of Mercuric Chloride and Semesan on Infested Corms

Treatment	Number of tests	Number of corms	Duration of treatment	First examination after 5 days		Second examination after 1 month	
				Number of insects	Per cent mortality	Number of insects	Per cent mortality
Mercuric chloride, 1–1000	2	20	2 hr.	179	99	47	96
Mercuric chloride, 1–1000	1	10	4 hr.	75	99	38	100
Semesan, 1 oz. to 1 gal.........	1	10	7⅔ hr.	51	100	23	100
Check (No treatment)	3	30	....	299	28	76	67

In this table it may be seen that all treatments indicated a high degree of kill, as shown by the first examination. According to the second examination, a mortality of 96 per cent was obtained with a 2-hour treatment of bichloride, as compared to 100 per cent when the duration of the treatment was 4 hours. These data and those of other tests, as well as the common experience of growers, would indicate that the corms should be treated for at least 4 hours in order to be sure they are clean. The Semesan treatment killed 100 per cent of the insects, according to the results of both the first and second examinations. In all the tests where Semesan was employed, it gave 100 per cent kill, and, therefore, this material may be recommended with assurance as a control for the thrips on the corms. However, since mercuric chloride is cheaper than Semesan and almost as efficient against the thrips, it is more commonly recommended by the Ohio Station.

Further consideration of the evidence presented in the table indicates that if any eggs on the treated corms escaped the treatment, the young larvae hatching therefrom were eventually killed by the residual effect of the materials. This raises the point whether field infestations might not arise if dipped corms were planted immediately after treatment, since the residual effect might be decreased to such an extent that the young would escape. It would seem that a safer plan would be to treat the corms at least 2 or 3 weeks previous to planting. It is barely possible that this factor may account for the very occasional report of the failure of the bichloride of mercury treatment to control this insect.

In summarizing the work concerning the control of this insect on the corms in storage, the data presented show that the grower may choose between the following treatments which were demonstrated to be nearly equal in efficiency:

Treatment	Concentration	Duration of treatment
1. Ethylene dichloride (3 parts)-Carbon tetrachloride (1 part)	14 lb.-1000 cu. ft.	24 hr.
2. Calcium cyanide	5 oz.-1000 cu. ft.	24 hr.
3. Naphthalene flakes	1 oz.-100 corms	3 wk.
4. Mercuric chloride (Corrosive sublimate)	1 oz.-7½ gal.	4 hr.
5. Semesan	1 oz.-3 qt.	7 hr.

The first three materials listed can best be used in the fall; whereas the last two materials are dips and should be employed only in the spring. The ethylene dichloride (3 parts) – carbon tetrachloride (1 part) mixture has the advantage of cleaning up the corms in one fumigation, and, furthermore, a large number of corms can be treated at one time. This treatment may be of most value to the large grower. However, even when the large grower uses this fumigant, it seems advisable to construct a special, tight fumigation chamber with a capacity of 50 to 100 bushels. Pressboard serves this need admirably.

Calcium cyanide is satisfactory for use by the large grower, but two or possibly three fumigations are necessary in order to clean up the corms. The thrips eggs are unaffected by the first treatment and a second or even a third fumigation may be necessary to kill the hatching larvae before they have an opportunity to reach the adult stage. Moreover, cyanide gas is a deadly poison and great caution must be taken when it is used.

Naphthalene in flake form is a slow-acting fumigant but one which is deadly to the thrips. It does not kill the eggs in the tissues of the corms but it kills the young, newly hatched larvae. When naphthalene is used, the corms should be placed in paper bags or in covered trays in order to confine the slowly evolved gas. Naphthalene probably will be most widely used by the home gardener or amateur grower, who, as a rule, has only small lots of corms to treat. This material is inexpensive and it is non-injurious to man. In some tests, where naphthalene was used on corms which had sprouted, a discoloration of the young tissue was noted. It, therefore, seems advisable to treat the corms with naphthalene during the dormant period only. The excess naphthalene should be removed before spring; otherwise injury may result.

If treatment is delayed until spring, either mercuric chloride or Semesan should be used, because both of these mercurial dips have additional fungicidal value against gladiolus diseases. In the event fall fumigation fails to control, the use of a dip in the spring is a cheap insurance for the summer flower crop. Inasmuch as both of these materials react with metal, they should be used in wooden or earthen vessels only. They are also quite poisonous and, as such, should be used with caution around children and livestock.

The foregoing corm treatments have been considered primarily from the standpoint of thrips control. The section to follow deals with the effect of the treatments on corm development.

THE EFFECT OF CORM TREATMENT ON SUBSEQUENT CORM DEVELOPMENT

In evaluating treatments of corms in storage, not only must the effects on the thrips be noted, but the possible effect on subsequent growth of the corms must likewise be taken into consideration.

Preliminary experiments to obtain data on this point were conducted in 1932. The corms were treated in the fall after they had been permitted to cure. No injurious effects were observed from any of the materials used, but it was noted that, if the several lots were kept in a moderately warm storage, those treated with a mixture of ethylene dichloride and carbon tetrachloride broke dormancy somewhat earlier than those treated with other materials. If held at a low storage temperature, however, development was normal.

In order to obtain more specific and precise information upon the effect of treatment on development, an experiment was designed and executed during the spring and summer of 1933. The corms were treated May 4, at which time there was no evidence of sprouting. They were planted in the field 2 weeks later. Each treatment involved 100 corms divided into five lots of 20 corms each, which were planted in five single-row plots located in different parts of the planting.

During the summer, data were taken on the following points and recorded for each plot separately: (a) Number of plants, (b) height of plant from ground to tip of longest leaf, (c)[4] number of flowers, (d)[4] height of spike from ground to tip, (e) length of spike from base of first floret to spike tip, (f)[4] blooming date (weighted mean), (g) number of corms at harvest, (h)[4] weight of harvested corms, and (i) weight per corm.

The corm treatments given and the records taken during the summer are indicated in Table 17.

When the data on the number of flowers, which are shown in Section A of the table, were analyzed (7), it was found that, as far as number per plot was concerned, there was no significant difference between the various treatments. The largest number of flowers was obtained from the corms treated with Semesan, with an average of 25 per plot; whereas the smallest number occurred in the check, with an average of 18.

In regard to the data showing height of spike, which appear in Section B, again no significant difference was found between treatments. Although the data pertaining to the length of the spikes and the height of the foliage are not given in this table, the differences were even less significant than those shown in Section B.

When the effect of the treatments on date of blooming was considered, as shown in Section C, it was found that the difference in blooming date between some treatments was significant. Those treated with normal strength ethylene dichloride – carbon tetrachloride (14 pounds-1000) bloomed first and those with Goulac – Black Leaf 50, calcium cyanide, and with carbon disulphide emulsion followed in the order named. All treated corms, except those on which naphthalene flakes were used, bloomed earlier than the untreated checks. On these plots the blooms appeared simultaneously. Inasmuch as earliness of blooming usually is of advantage to the grower, it would seem that treatment with some of the materials could be considered of value aside from the standpoint of thrips control.

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[4]These measurements were considered to be of most vital interest to the grower. For this reason the other data taken are not placed on record at this time.

TABLE 17.—Effect of Different Treatments on Subsequent Corm Development

Treatment	Section A						Section B						Section C						Section D					
	Number of flowers						Spike height, in inches						Blooming date†						Corm weight, in ounces					
	Replications						Replications						Replications						Replications					
	1	2	3	4	5	M*	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M
Naphthalene flakes, 1 oz. to 100 corms. Exposure 2 weeks	15	24	21	15	19	19	32	31	32	33	29	31	21	23	24	20	22	22	23	31	32	26	31	29
Eth. dich.-carb. tetr., 28 lb. to 1000 cu. ft. Exposure 24 hours.	16	22	20	20	17	19	33	33	34	31	26	31	19	20	19	19	22	20	24	28	28	27	24	26
2% free nicotine dust. Exposure 2 weeks	18	20	20	24	20	20	37	31	34	31	31	33	23	21	17	21	18	20	25	23	32	30	30	28
Calcium cyanide, 5 oz. to 1000 cu. ft. Exposure 24 hours	22	19	19	31	14	21	31	33	32	29	32	31	21	17	14	20	19	18	33	34	40	28	25	32
Eth. dich.-carb. tetr., 14 lb. to 1000 cu. ft. Exposure 24 hours.	27	18	18	17	19	20	33	31	33	28	30	31	19	14	12	21	21	17	33	32	38	23	35	22
Mercuric chloride, 1 oz. to 7½ gal. Exposure 3 hours	27	24	24	24	14	23	34	35	32	35	31	33	19	22	18	23	21	21	39	32	38	39	36	37
Semesan, 1 oz. to 3 qt. Exposure 7 hours	27	27	28	17	24	25	34	34	31	29	32	32	21	20	21	22	21	21	33	45	42	20	40	36
Goulac 1%-B. L. 50, 1-379. Exposure 3 hours	18	22	16	23	14	19	34	31	32	31	31	32	18	16	15	19	19	17	25	28	18	26	30	25
Carbon disulphide, 1-1000. Exposure 3 hours	25	17	21	24	21	22	32	31	32	32	31	32	18	18	17	23	18	19	26	19	28	36	34	29
Check (No treatment)	21	19	12	23	16	18	34	31	32	32	30	32	22	22	21	20	26	22	22	31	19	29	20	24

*M=Mean or average.
†All blooming in August; for example, August 21, 23, etc.

In Section D, showing the weight of the corms at harvest, it may be seen that the treatments with mercuric chloride, ethylene dichloride – carbon tetrachloride mixture (14 pounds-1000), and calcium cyanide, in the order named, gave the largest corm production. The increase in corm yield from all these treatments was significant when compared with the check. The remaining treatments, although somewhat better than the check from the standpoint of yield, were not significant. When the number of corms and the weight per corm were considered, no difference in these respects was noted.

All the evidence obtained from the various measurements made on the subsequent growth of treated corms in this experiment indicates that no injurious effect was produced. On the other hand, some beneficial results, as, for example, earlier blooming flowers and increased corm production, were obtained.

CONTROL ON GROWING PLANTS

Even though effective corm treatments are known, it will always be necessary to have some efficient measure available for controlling this thrips in the field. This would benefit especially those growers who fail to apply effective corm treatments and the home gardener who unknowingly plants infested corms. During the 3-year investigation of this problem, a diligent search was made to find an efficient field treatment. Many tests were conducted with living plants in the laboratory and greenhouse, and an extensive insecticide program was carried out in the field each year. A discussion of the methods of experimentation used and the results obtained is given in the following section.

LABORATORY AND GREENHOUSE TESTS

The purpose of the laboratory and greenhouse tests was to obtain some definite information relative to the effectiveness of different materials before they were subjected to field experimentation. Their particular significance is their value as indices to needed field work. It may be noted, however, that the results of all types of tests, in the main, were quite comparable. The following methods were used: (a) The plant section method, (b) the growing plant method, and (c) the caged plant method. Each of these methods will be treated in detail in the following discussion.

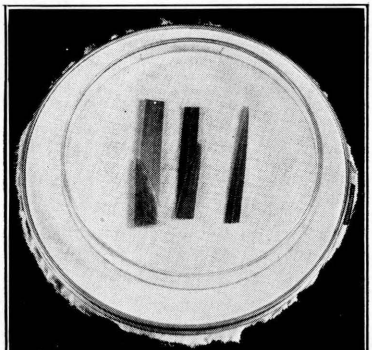

Fig. 10.—Assembly used in detailed spray tests for thrips on foliage. See text "Plant Section Method".

LABORATORY TESTS WITH PLANT SECTION METHOD

The insects used in these tests were taken from heavily infested plants grown in the greenhouse. After the plants were sprayed, the leaves were cut in convenient lengths and placed on pieces of muslin stretched tightly over embroidery rings. In most of the tests about 100 insects were used per ring, and a shallow glass dish was inverted over the leaf sections (Fig. 10). This prevented the surviving insects from escaping. In the majority of instances, a section of a check plant, which was sprayed with water only, was included.

Examinations to determine the degree of control were made after an interval of 24 hours. The materials tested and the results obtained appear in Table 18.

TABLE 18.—Sprays Used on Infested Plants in Laboratory

Treatment Spray materials combined in 1 gallon of water	Per cent mortality					
	Replications					
	1	2	3	4	5	Mean
Test No. 1						
Sulph. waste, 26 cc.—B. L. 50, 10 cc.—L. Ars., 15 gm..........	95	99	......	......	......	97
Sulph. waste, 26 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..........	59	91	......	......	......	75
Penetrol, 18 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..............	53	54	......	......	......	54
M-P spray, 25 cc.—L. Ars., 15 gm.............................	43	54	......	......	......	49
Derrisol, 10 cc.—L. Ars., 15 gm..............................	40	30	......	......	......	35
Check (water)..	4	......	......	......	......	4
Test No. 2						
Sulph. waste, 26 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..........	100	98	52	......	......	83
Derrisol, 10 cc.—F. O. S., 10 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm.	98	95	98	......	......	97
Check (water)..	6	......	......	......	......	6
Test No. 3						
Sulph. waste, 26 cc.—B. L. 50, 10 cc.—L. Ars., 15 gm..........	51	58	49	......	......	53
Verdol, ½ per cent—B. L. 40, 10 cc.—L. Ars., 15 gm..........	45	76	21	......	......	47
Check (water)..	18	......	......	......	......	18
Test No. 4						
Sulph. waste, 26 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..........	72	70	82	......	......	75
Penetrol, 18 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..............	32	27	18	......	......	26
Derrisol, 10 cc.—L. Ars., 15 gm..............................	81	100	95	......	......	92
Check (water)..	11	......	......	......	......	11
Test No. 5						
Sulph. waste, 26 cc.—B. L. 40, 10 cc.—L. Ars., 15 gm..........	66	67	37	68	37	55
Sulph. waste, 26 cc.—B. L. 50, 10 cc.—L. Ars., 15 gm..........	75	95	85	97	91	89

In general, the low average percentage of mortality obtained with the sprays, which is shown in this table, indicates that the gladiolus thrips is hard to kill. The combination of sulphite waste - Black Leaf 40 - lead arsenate usually gave a higher kill than the other sprays compared with it. However, when Black Leaf 50 was used instead of Black Leaf 40 in this combination, the percentage of kill was increased perceptibly. The best wetting was obtained with Derrisol, Penetrol, and M-P Spray, in the order named.

GREENHOUSE TESTS WITH GROWING PLANT METHOD

On January 19, 1931, 100 gladiolus corms were planted in 4-inch pots for thrips work. These corms had been harvested in the fall and kept in common storage in the basement. On February 10, the potted plants had obtained sufficient growth and infestation to warrant the starting of the spray tests. Accordingly, they were arranged in 10-plant plots on a raised ground bench in the greenhouse. The sprays were applied at weekly intervals, with one exception; however, all the sprays were not started at the same time. The materials tested and the total number of thrips, which were counted just before spraying and again after an interval of 24 hours, are given in Table 19.

TABLE 19.—Sprays Used on Infested Plants in Greenhouse. Test No. 1

Date of spray application	Verdol 1% Black Leaf 40 1-800			K. O. S. ¾% Black Leaf 40 1-800			Sulphite Waste ½% Black Leaf 40 1-800			Penetrol ½% Black Leaf 40 1-800			Check
	No. insects		% mort.	No. insects		% mort.	No. insects		% mort.	No. insects		% mort.	No. insects
	Before	After		Before	After		Before	After		Before	After		Before
February 10	19	2	90	27	7	74	....	....	....	....	....	....	30
February 17	50	3	94	32	5	84	33	2	94	....	....	....	52
February 24	226	7	97	109	3	97	188	1	100	....	....	....	370
March 10	56	1	98	29	9	69	3	0	100	110	11	90	419
March 17	316	11	97	165	29	82	55	4	93	226	5	98	1510
Total	667	24	....	362	53	....	279	7	....	336	16	....	2381
Average	....	....	96	....	....	85	....	....	98	....	....	95	....

*K. O. S.—Potassium oleate soap.

In this table, it may be seen that when Black Leaf 40 was used with Verdol, sulphite waste, and Penetrol, the insects were held in check, inasmuch as the average percentage mortality after five applications was from 93 to 96 per cent. The treatment of potassium oleate soap plus Black Leaf 40 gave the lowest kill. It will be noted that during the 7-day interval between sprays, in all instances, regardless of the material used, there was a considerable degree of recovery in numbers; hence, the necessity for weekly applications is demonstrated. It will be observed also that the check plots built up a very heavy population during the course of the test. When the effect of the sprays on the plants was noted, it was found that the plants in the Verdol plot were flabby and the tips of the leaves showed some burning. It seems, therefore, that it may be dangerous to spray too often with Verdol unless intervening rains wash off some of the oil.

During the fall of 1931, another experiment was conducted in a manner similar to the one just described. The materials tested and a record of the living thrips counted before spraying and 24 hours after are given in Table 20.

The results in this table indicate how difficult it is to control this pest on growing plants when the infestation has become severe before any control measures are applied. Derrisol alone and Black Leaf 40 in combination with Penetrol and sulphite waste gave about 70 per cent control; whereas the combination of sulphite waste and Black Leaf 50 again gave a higher percentage of kill (84%). The M-P spray and sulphonated fish oil sprays gave the best control, but the application of these materials was started later than the others of the series. When this experiment was concluded, the plants in the sprayed plots were still green; whereas those in the check were practically dead as a result of insect injury. When gladiolus plants become too heavily infested, the insects migrate for the lack of food; this was apparent in the check plot, where the population gradually diminished. Undoubtedly, many insects which left the check flew to the treated plots after the application of sprays was made; this is particularly evident in several cases where more insects were found on the plants after the sprays were applied than before. This experiment demonstrated that it is essential to eliminate the migration factor in order to be able to evaluate the relative efficiency of several sprays of a given series to any degree of certainty. This was accomplished by the use of celluloid cages in which the growing plants were confined.

GREENHOUSE TESTS WITH CAGED PLANT METHOD

During the spring of 1932, 12 series of greenhouse tests were conducted to determine the relative efficiencies of common spray mixtures for the control of gladiolus thrips on growing plants. The varieties of gladioli used in these tests were 1910 Rose, America, and Crimson Glow. The total number of spray formulae tested was 25. The results are given in Tables 21, 22, 23, 24, 25, and 26.

The experimental unit consisted of one plant and, with one exception, each treatment was replicated five times. A celluloid cylinder 8 inches in diameter and 20 inches high, with the upper end covered with muslin, enclosed each plant in order to confine the thrips and prevent migration from other plants. A large square of cotton was draped about the base of each plant and made to rest on a ¼-inch mesh wire platform, which, in turn, was supported by the

TABLE 20.—Sprays Used on Infested Plants in Greenhouse. Test No. 2

Date of spraying	Penetrol ½% B. L. 40 1-279 L. Ars. 1½ lb.-50			Derrisol 1-379 L. Ars. 1½ lb.-50			L. Ars. 1½-50 S. W. 3¼%+ B. L. 40 1-379			S. W. ¾%+ B. L. 50 1-379 L. Ars. 1½ lb.-50			M-P Spray 13 cc. per gallon L. Ars. 1½ lb.-50			Fish oil soap ½% B. L. 40 1-379 L. Ars. 1½ lb.-50			Check
	No. insects		Av. % mort.	No. insects		Av. % mort.	No. insects		Av. % mort.	No. insects		Av. % mort.	No. insects		Av. % mort.	No. insects		Av. % mort.	Av. of counts
	Be-fore	Af-ter		Be-fore	Af-ter		Be-fore	Af-ter		Be-fore	Af-ter		Be-fore	Af-ter		Be-fore	Af-ter		
September 23	141	31	78	47	17	64	135	98	27	......	......	....	......	......	....	......	......	....	525
September 25	175	49	72	18	20	....	278	46	84	......	......	....	......	......	....	......	......	....	1072
September 28	88	47	47	29	6	79	252	9	96	1510	87	94	1373	72	95	......	......	....	1611
September 30	95	54	43	14	20	....	73	60	18	264	138	47	268	29	89	......	......	....	1069
October 2	112	30	64	23	4	83	73	29	60	179	91	49	30	13	57	617	42	93	692
October 12	163	5	97	94	4	96	110	12	89	397	38	90	26	1	96	238	20	92	219
October 19	43	8	81	23	9	61	18	20	....	83	29	65	18	9	50	39	27	31	73
Total	817	224	73	248	80	68	939	274	71	2433	383	84	1715	124	92	894	89	90	5261

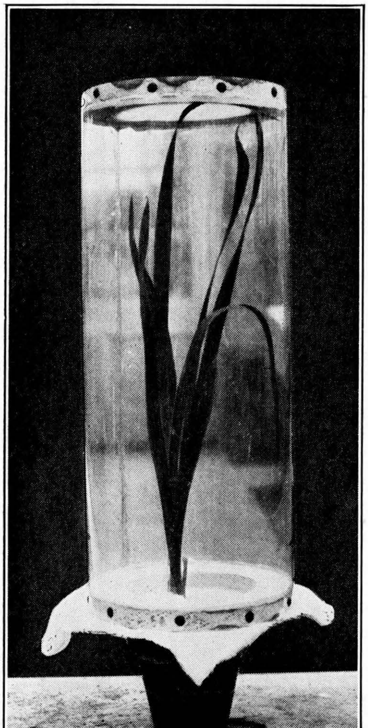

Fig. 11.—Caged growing plant method used in evaluating sprays for thrips on foliage. The cage prevents migration to or from the plant

4-inch pots containing the growing plants. See Figure 11. The wooden bases of the cages had a tendency to sink into the cotton, and, consequently, no insects could easily escape. The wire platforms at the bottom and the muslin at the top of the cage afforded ample ventilation.

All the plants for these tests were grown in a cloth-enclosed bench in the greenhouse and, therefore, were free of any infestation at the beginning of each experiment. Later, at the proper time, each plant was infested with approximately 30 adults. The insects were collected in 6-inch glass tubes ⅞ inch in diameter by means of a small suction apparatus. After 30 insects were collected in each tube, it was plugged with cotton. Later, one tube was placed with each inclosed plant and the plug removed. Within an hour most of the insects migrated to the plants. However, in most cases, a few insects died in the vials, but these were not considered in the experiment.

The celluloid cages were employed for evaluating two types of material: First, those which it was hoped would have a residual effect, thus destroying the insects when they fed upon or crawled over the treated surface; and, second, those intended to kill immediately by initial contact. Because of the variation in the objectives sought, it became necessary to follow a little different technique with respect to handling the insects involved in the two experiments. This will be discussed in detail with each.

EVALUATION OF RESIDUAL EFFECT OF SPRAYS ON CAGED PLANTS IN GREENHOUSE

In order to determine the residual value of spray materials, plants free of insects were sprayed and placed in the celluloid cages previously described. After the excess moisture had disappeared from the plants, approximately 30 adult thrips were liberated in each cage. A period of 10 days was allowed to elapse for the effect of the spray material to take place. To have allowed a longer lapse of time would have complicated the record, because adults of a new generation would have appeared. At the end of the 10-day period, the living adults and larvae were counted, but a separate record of each stage was kept. When the data were analyzed it was found that reproduction was exemplified by the number of living larvae and, for the most part, was directly proportional to the degree of efficiency of each of the several materials used. Thus, if a spray effected a good kill of the introduced adults, few larvae were produced and vice versa. For purposes of analysis (7), adult mortality is adequate; hence, this alone will be recorded in Tables 21, 22, and 23.

TABLE 21.—Residual Effect of Sprays on Adult Thrips in Greenhouse. Test No. 1

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality						
		Replications						Mean
		1	2	3	4	5	6	
1	Paris Green .... 2 tsp. Brown sugar .... 303 gm.	100	100	100	100	100	100	100
2	Goulac .... 39 cc. Black Leaf 40 .... 10 cc.	100	100	100	95	91	100	98
3	Goulac .... 19 cc. Black Leaf 40 .... 10 cc. S. fish oil .... 19 cc.	94	100	87	100	88	91	93
4	Goulac .... 19 cc. Black Leaf 40 .... 10 cc. S. fish oil .... 19 cc. Lead arsenate .... 15 gm.	77	71	86	100	81	88	84
5	Check (No treatment)	79	71	20	96	50	61	63

TABLE 22.—Residual Effect of Sprays on Adult Thrips in Greenhouse. Test No. 2

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality					
		Replications					Mean
		1	2	3	4	5	
1	Goulac .... 39 cc. Paris Green .... 2 tsp.	100	100	100	100	100	100
2	Goulac .... 39 cc. Black Leaf 40 .... 5 cc. Paris Green .... 1 tsp.	100	100	100	100	100	100
3	Goulac .... 39 cc. Black Leaf 40 .... 10 cc.	95	100	100	92	100	97
4	Goulac .... 39 cc. Black Leaf 50 .... 10 cc.	93	86	75	83	77	83
5	Paris Green .... 2 tsp. Brown sugar .... 151 gm.	100	91	100	88	93	94
6	Goulac .... 31 cc. S. fish oil .... 8 cc. Black Leaf 40 .... 10 cc. Lead arsenate .... 18 gm.	78	73	47	92	62	70
7	Goulac .... 31 cc. S. fish oil .... 8 cc. Black Leaf 40 .... 10 cc.	73	81	46	67	47	63
8	Check (No treatment)	65	23	33	17	13	30

In general, it was surprising to find the high percentage of kill which is shown in this table. Although the mortality in the check was high, the differences between it and all the treatments were significant (7). The data of this table do not fully indicate the degree of significance between the check and the treated plots which was strikingly apparent at the time the visual examination of the plants in the various plots was made. No appreciable differences occurred between the first three sprays listed in this table, but the first two of the series are significantly better than the fourth one. Paris Green and brown sugar gave 100 per cent adult mortality in this test. This indicates that this spray has an effective residual value when allowed to act over a period of time. Although the data are not included in this table, it may be stated parenthetically that all newly hatched larvae also were killed.

Treatments 1, 2, 3, and 5 of this table gave a high mortality and the differences between them were not significant (7). All the treatments were significantly better than the check. When a part of the Goulac in the Goulac – Black Leaf 40 combination was replaced by sulphonated fish oil, the efficiency of the spray was materially decreased. This was somewhat perplexing, because it was realized that the Goulac combinations did not wet gladiolus foliage properly and it was hoped that the fish oil would remedy this defect. Many attempts to improve the wetting properties of the Goulac combinations resulted in a significant decrease in toxicity. It was also noted that Paris Green and brown sugar gave very poor wetting; however, this spray seemed to be quite toxic to the insect when allowed to act over a period of time. A further study of this table shows that, when Black Leaf 50 was used with Goulac instead of Black Leaf 40, the efficiency of the mixture decreased significantly. This was directly opposite to the results obtained when the materials were used on plants infested with insects at the time sprays were applied. This will be shown later in Tables 24 and 25.

The results of the third and final test are shown in Table 23.

TABLE 23.—Residual Effect of Sprays on Adult Thrips in Greenhouse. Test No. 3

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality					
		Replications					Mean
		1	2	3	4	5	
1	Derrisol ....39 cc. Calcium arsenate..........18 gm.	100	100	100	100	92	98
2	Lignin Pitch................39 cc. Black Leaf 40................10 cc.	96	84	95	100	92	93
3	Lignin Pitch................39 cc. Black Leaf 40................10 cc. Calcium arsenate ....18 gm.	100	93	83	86	73	87
4	Lignin Pitch................39 cc. Black Leaf 50................10 cc. Dutox.......................18 gm.	68	95	73	77	56	74
5	Verdol ....39 cc. Black Leaf 40................10 cc. Calcium arsenate ....18 gm.	84	80	52	76	95	77
6	Check (No treatment)...........	52	44	15	46	33	38

A study of this table shows that Derrisol was the best treatment and the Lignin Pitch combination was next. The addition of calcium arsenate seemed to decrease the efficiency of the sprays in which it was used. The differences between the first three sprays listed are not significant. The mixture of Lignin Pitch – Black Leaf 50 – Dutox not only gave a lower kill but considerable burning occurred on the plants. The Verdol – Black Leaf 40 spray was significantly less toxic to the adults than either the Derrisol – calcium arsenate or Lignin Pitch – Black Leaf 40 – calcium arsenate mixture, as shown in Column 2 of this table.

Inasmuch as Lignin Pitch, Goulac, and sulphite waste have all been used in some of the laboratory and greenhouse tests, something about their history will be given. Sulphite waste is a liquid by-product from the manufacture of paper from wood pulp. Goulac, Lignin Pitch, and Bindex are the dry and powdered forms of sulphite waste. When this material proved to be a good spreader for contact insecticides, different firms began handling it and each gave it a different trade name. When the powdered forms were used in these tests, they were converted into sulphite waste by adding an equal weight of water to the powder several days before the sprays were applied. Certain amounts of this stock solution were then used in the spray combinations. Some tests were conducted to determine the differences between the different forms of sulphite waste, and the results showed that any of the forms could be used interchangeably without affecting the results.

EVALUATION OF CONTACT SPRAYS ON CAGED PLANTS IN GREENHOUSE

In the tests conducted for the purpose of evaluating contact sprays on gladiolus plants growing under greenhouse conditions, the same type of celluloid cage employed in the immediately preceding series of tests was used. The only difference in procedure was that, after the plants were placed in the cages, the insects were liberated therein and allowed a period of 6 to 10 days to reproduce before the plants were sprayed. All sprays were applied with a small, hand sprayer.

Twenty-four hours after spraying the plants were carefully examined and the dead and living insects noted. Records of adults and larvae were kept separately. It was found, however, that adult mortality was slightly higher than that of the larvae but the ratio was so nearly constant throughout the series of tests that the kill of both is considered as a composite record.

It will be observed that many of the formulae contained stomach poisons, but it is believed these had little influence on the records of kill because a 24-hour period only elapsed before the records were taken. The results obtained on the variety 1910 Rose are given in Table 24.

Among the materials listed in this table, Cubor and the combination containing Goulac, Black Leaf 50, calcium arsenate, and C. P. O. soap gave kills of 98 and 96 per cent, respectively. In general, these two sprays were considerably better than the Derrisol and Goulac – Black Leaf 50 combinations, although the differences were a little too small to be significant (7) in any case. The C. P. O. soap, which was added to the Goulac – Black Leaf 50 combination, increased the efficiency of the combination considerably. Although Cubor ranked high in these tests, it was less effective in the field, as will be shown later. A further study of this table reveals that the addition of calcium arsenate to mixtures of Goulac and either Black Leaf 40 or Black Leaf 50 increased the efficiency of the combination. The data also show that neither Penethrum nor Nicotrol, when used at the strengths indicated, offer any promise as thrips controls. The percentage mortality in all the checks was comparatively low.

TABLE 24.—Percentage of Thrips' Mortality from Sprays on Variety 1910 Rose in Greenhouse

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality					
		Replications					Mean
		1	2	3	4	5	
	Test No. 1						
1	Goulac ....39 cc. Black Leaf 40 ....10 cc. Calcium arsenate ....18 gm.	51	84	78	68	84	73
2	Goulac ....39 cc. Black Leaf 50 ....10 cc. Calcium arsenate ....18 gm.	73	84	90	69	77	79
3	Goulac ....39 cc. Black Leaf 40 ....10 cc.	33	33	39	34	28	33
4	Check (No treatment)...........	4	2	3	1	3	3
	Test No. 2						
5	Goulac ....39 cc. Black Leaf 50 ....10 cc. Calcium arsenate ....18 gm.	81	98	97	90	66	86
6	Goulac ....39 cc. Black Leaf 50 ....10 cc. Calcium arsenate ....18 gm. C. P. O. soap..............15 cc.	98	99	100	94	87	96
7	Goulac ....39 cc. Black Leaf 50 ....10 cc. Paris Green..................1 tsp.	91	93	95	100	55	87
8	Check (No treatment)...........	1	1	0	3	9	3
	Test No. 3						
9	Goulac ....39 cc. Black Leaf 50 ....10 cc.	72	25	54	39	95	57
10	Nicotrol....................30 cc.	28	17	14	15	42	23
11	Cubor.......................30 cc.	99	95	100	95	100	98
12	Penethrum..................30 cc.	85	45	53	27	31	48
13	Check (No treatment)...........	1	3	27	1	1	7
	Test No. 4						
14	Goulac ....39 cc. Black Leaf 50..............10 cc. Calcium arsenate...........18 gm.	92	89	52	82	92	81
15	Goulac ....39 cc. Black Leaf 50..............15 cc. Calcium arsenate...........18 gm.	88	87	87	95	72	86
16	Derrisol ....20 cc. Calcium arsenate ....18 gm.	88	76	84	96	89	87
17	Check (No treatment)...........	4	2	7	3	2	4

The next test of this series was conducted on the variety America. The results obtained are shown in Table 25.

TABLE 25.—Percentage of Thrips' Mortality from Sprays on Variety America in Greenhouse

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality					
		Replications					Mean
		1	2	3	4	5	
Test No. 1							
1	Goulac ....39 cc. Black Leaf 40 ....10 cc.	88	63	99	78	79	81
2	Goulac ....39 cc. Black Leaf 40 ....10 cc. S. fish oil ....8 cc.	33	28	55	67	55	48
3	Paris Green..... ....2 tsp. Brown sugar ... .303 gm.	17	21	13	17	22	18
4	Check (No treatment)...........	2	0	0	1	1	1
Test No. 2							
5	Goulac .... 39 cc. Black Leaf 50 .... 5 cc. Black Leaf 40 .... 5 cc. Calcium arsenate ....18 gm.	100	97	100	96	96	98
6	Derrisol ....10 cc. Calcium arsenate ....18 gm.	93	93	94	100	.96	95
7	Goulac ....39 cc. Black Leaf 50 ....10 cc. Paris Green..................1 tsp.	100	100	97	99	89	97
8	Derrisol ....10 cc. Penetrol.......... .... 5 cc. Calcium arsenate ....18 gm.	82	86	97	100	100	93
9	Goulac ....39 cc. Black Leaf 50 ....10 cc. Calcium arsenate ....18 gm.	99	100	100	99	98	99
10	Check (No treatment)...........	52	1	29	67	50	40

Three of the Goulac-nicotine combinations and the two of Derrisol gave controls ranging from 93 to 99 per cent. Although the differences between these five spray materials were not significant (7), they were almost all significantly better than the Goulac – Black Leaf 40 combination, which gave a mortality of 81 per cent. The addition of a small amount of sulphonated fish oil soap to this spray decreased its efficiency 34 per cent, which is a significant difference. A further study of this table shows that a 24-hour period is insufficient to permit the Paris Green – brown sugar treatment to become effective. However, Paris Green and brown sugar have considerable residual value, and it is rather efficient when allowed to act over a longer period of time. This was demonstrated in an earlier section.

Table 26 gives the results obtained on the variety Crimson Glow.

Of the five materials tested on Crimson Glow, the Red Arrow – C. P. O. soap – calcium arsenate combination gave the highest kill. However, it was not significantly (7) better than the first, third, and fourth treatments listed in this table and neither did the addition of C. P. O. soap to Red Arrow signicantly increase the efficiency of the material. The Derrisol – calcium arsenate spray gave the lowest kill and this combination was significantly less effective than the first and sixth treatments listed in the table.

TABLE 26.—Percentage of Thrips' Mortality from Sprays on Variety Crimson Glow in Greenhouse

Treatment No.	Spray materials combined with one gallon of water	Per cent mortality — Replications 1	2	3	4	5	Mean
1	Goulac ....39 cc. Black Leaf 50 ....10 cc. Calcium arsenate ....18 gm.	97	96	96	95	94	96
2	Derrisol ....10 cc. Calcium arsenate ....18 gm.	87	91	93	97	87	91
3	Goulac ....39 cc. Black Leaf 50 .... 5 cc. Derrisol .... 5 cc. Calcium arsenate ....18 gm.	99	95	100	91	89	95
4	Red Arrow ....10 cc. Calcium arsenate ....18 gm.	98	90	96	100	92	95
5	Red Arrow ....10 cc. C. P. O. soap ....15 cc. Calcium arsenate ....18 gm.	97	100	98	99	97	98
6	Check (No treatment)............	2	1	3	5	1	2

FIELD TESTS—1931

Some preliminary field tests were conducted during the summer of 1931 at Wooster, Ohio, on the variety 1910 Rose. A very light infestation developed in the plots, and, consequently, the results obtained were not very conclusive. The infestation in the early planting in particular was so light that no insect records were taken, but, in the late planting, the thrips became more abundant and some counts were made. The experimental unit consisted of four rows of 25 plants each, and each treatment was replicated twice. One border row separated the plots in one direction and a vacant space about 18 inches wide separated them the other way. Seven treatments were applied to both the early and late plantings at weekly intervals beginning on July 6 and ending August 31. All the sprays were applied with a hand sprayer at a pressure of about 150 pounds. When the flowers started to appear, a daily record thereafter was taken. On four occasions during the blooming season, records were taken of the degree to which the flowers were damaged. These records were obtained by counting the total number of expanded florets and noting the number which showed thrips injury. When the corms were dug, a record of the yield, including both the number and weight of corms for each plot, was secured. The percentage of injured florets is given in Table 27.

In general, the replications are too few to evaluate the effectiveness of treatments to any degree of certainty. The materials used are arranged in the table in the ascending order of their efficiency. It is interesting to note that the sequence of the sprays given in this table is very similar to that shown in

TABLE 27.—Percentage of Thrips' Injured Florets from Field-sprayed Plots, 1931

Treatments	Per cent of injured florets		
	Replications		
	1	2	Mean
Sulphite waste ... ¾% Black Leaf 40 ... 1-378	50	53	52
Verdol ... ½% Black Lesf 40 ... 1-378	58	65	62
2% free nicotine dust ...	58	67	63
K. O. soap ... ¾% Black Leaf 40 ... 1-378	60	78	69
Penetrol ... 1½% Black Leaf 40 ... 1-378	83	72	78
M-P Spray ... 1 pt.-50 gal.	96	80	88
Check (No treatment) ...	87	72	80

TABLE 28.—Effect of Sprays on Plants in Field Plots, 1931

Treatments and composition of each ingredient	No. replications	No. flowers	Average blooming date	No. corms per plot	Wt. in lb. per 100 corms
Section A. Early Planting					
Sulphite waste ... ¾% Black Leaf 40 ... 1-378	2	139	Aug. 20	102	7.93
Verdol ... 1% Black Leaf 40 ... 1-378	2	143	Aug. 21	97	8.00
Paris Green ... 2 tsp. Brown sugar ... 2 lb. Water ... 3 gal.	2	139	Aug. 21	106	4.59
KO soap ... ¾% Black Leaf 40 ... 1-378	2	173	Aug. 21	118	6.92
M-P Spray ... 1 pt.-50 gal.	2	136	Aug. 22	91	8.03
Penetrol ... ½% Black Leaf 40 ... 1-378	2	142	Aug. 19	103	7.84
Check (No treatment) ...	2	149	Aug. 19	104	8.46
Section B. Late Planting					
KO Soap ... ¾% Black Leaf 40 ... 1-378	2	...	...	121	5.24
Penetrol ... ½% Black Leaf 40 ... 1-378	2	...	...	111	5.46
Sulphite waste ... ¾% Black Leaf 40 ... 1-378	2	...	...	133	5.85
Verdol ... 1% Black Leaf 40 ... 1-378	2	...	...	133	5.02
M-P Spray ... 1 pt.-50 gal.	2	...	...	122	5.56
Free nicotine dust ... 2%	2	...	...	130	5.76
Check (No treatment) ...	2	...	...	135	4.79

the laboratory and greenhouse tests (Tables 18 and 19). The effect of the different spray combinations on the development of plants in both the early and late plantings is summarized in Table 28.

In the column of Section A of this table showing the number of flowers, it may be seen that the flower yield for all the treatments was quite uniform, except for the K. O. S. treatment where, for some unknown reason, a larger number of flowers was obtained. When the last column, showing the weight per 100 corms is considered, the two treatments, Paris Green – brown sugar and potassium oleate soap – Black Leaf 40, gave the lowest yield of corms. This reduction in yield for these treatments was significantly (7) lower than the yield of the checks. Moreover, the spray injury to the foliage of these treatments was quite apparent, especially after the fourth spray application. The soap and Paris green had a tendency to concentrate in and around the lower leaf-sheaths, which turned brown, and eventually all of the lower leaves died. It, therefore, seemed inadvisable to use soap spreaders on gladiolus foliage, and in later tests the concentration of Paris Green was decreased in an attempt to overcome the burning. The other sprays apparently had little or no effect on corm yield.

In addition to the aforementioned experiment, supplementary information was obtained during the summer of 1931 from some tests which were conducted in the heavily infested plantings of a grower. The sulphite waste – Black Leaf 40 – lead arsenate combination, as in the tests at Wooster, was the outstanding material, and, with few exceptions, the treatments used at both places were the same. The percentage of injured flowers in the treated plot was 27, as compared with 81 in the check, and the reduction in thrips population was 86 per cent. Most of the flowers from the treated plot were salable; whereas most of those from the check plot were thrown away.

FIELD TESTS—1932

Three varieties of gladioli—1910 Rose, Crimson Glow, and Alice Tiplady—were used in the insecticide tests of 1932. More corms of 1910 Rose were available; hence, the most comprehensive phase of the experiment was conducted on this variety. Infested corms were used purposely, and, in order to insure a satisfactory infestation in the plots, potted plants that had been heavily infested in the greenhouse were distributed at intervals throughout the planting before the treatments were started.

The corms were planted May 16. The experimental unit consisted of four rows of 50 corms each and the plots were randomized with four replications for each treatment. A total of six sprays was applied at weekly intervals with a power sprayer which maintained a pressure of from 250 to 300 pounds. The first application was made on June 21, when the plants were from 10 to 15 inches tall, and the last, when the plants began to shoot spikes. During the season, data were taken on height of plant, blooming date, flower injury by thrips, flower production, and corm production.

The flowers were examined and cut every 2 or 3 days throughout the blooming period. Two methods were used in recording thrips injury to the flowers. In the first method, the total number of open florets and those injured by thrips were recorded for each spike. In the second method, the general appearance of the open florets was considered and the spike was graded according to the following standards:

Grade 0—No injury, highest class of salability.

Grade 1—Slight injury, 1 or 2 petals of 1 or 2 florets flecked from thrips feeding. Second class of salability.

Grade 2—Moderate injury, a number of petals with severely flecked areas and curled margins. Not salable.

Grade 3—Severe injury, excessive flecking, and number of petals with crimped and curled margins. Not salable.

Grade 4—Very severe injury, flowers so badly damaged that they were unable to open. Not salable.

In this manner, two separate records were obtained at one examination. The first pertained to the number of injured florets per spike and the second to the grade of the spike, depending on the degree of thrips injury.

In the analysis (7) of all the insecticide data, which were taken in the field, it was found that the use of the first method of recording thrips injury was more applicable to light infestation conditions; whereas the second method should be used where heavy infestations of thrips prevailed.

When the records were taken on the plots in which the varieties Crimson Glow and Alice Tiplady were used, it was found that migration of the insects from the heavily infested varietal test plots, which were located nearby, had practically nullified the effects of the treatments; therefore, the results on 1910 Rose only are included here. Four of the most promising sprays and one dust were included in these tests. The percentage of injured florets in the several plots is shown in Table 29.

TABLE 29.—Percentage of Thrips-injured Florets from Field-sprayed Plots, 1932

Treatment No.	Treatments	Per cent injured florets				
		Replications				Mean
		1	2	3	4	
1	Paris green .... 17 tbsp. Brown sugar .... 16⅔ lb. Water .... 25 gal.	38	17	28	40	31
2	Goulac .... 975 cc. Black Leaf 50 .... 250 cc. Calcium arsenate .... 450 gm. Water .... 25 gal.	29	29	34	32	31
3	2% free nicotine dust (Diluent, hydrated lime)	33	28	38	45	36
4	Cubor .... 625 cc. Calcium arsenate .... 450 gm. Water .... 25 gal.	31	43	40	46	40
5	Derrisol .... 375 cc. Calcium arsenate .... 450 gm. Water .... 25 gal.	42	30	40	55	42
6	Check (No treatment)	50	45	51	74	55

In general, the infestation in these plots was not high, as is indicated by the check where the percentage of injured florets was only 55. However, all the treatments gave significant (7) protection, as is indicated when the infestation records are compared with those of the check or untreated plot.

The first four treatments listed in the table are not significantly different. Treatments 1 and 2, however, were superior to Treatment 5.

The effect of the various treatments on the plant and its development was considered in all field tests. It was realized that any satisfactory control measure must also be non-toxic to the plant. When the different criteria of plant tolerance were considered (as, for example, height of plant, blooming date, flower production, and corm production), it was found that the last named was the most important or significant measurement. Moreover, the degree of injury to the plant was not shown in the number of corms produced but rather in the quality as expressed in size and weight. When a treatment caused severe burning, the degree of injury was reflected in smaller and lighter corms. In Table 30 is shown the weight of the corms from each treatment.

TABLE 30.—Corm Yield in Pounds from Field-sprayed Plots, 1932

Treatment No.	Treatments	Yield in pounds				
		Replications				Mean
		1	2	3	4	
1	Paris green........17 tbsp. Brown sugar........16⅔ lb. Water........25 gal.	10	10	9	12	10
2	Goulac........975 cc. Black Leaf 50........250 cc. Calcium arsenate........450 gm. Water........25 gal.	13	15	13	14	14
3	2% free nicotine dust (Diluent, hydrated lime)	17	17	15	16	16
4	Cubor........625 cc. Calcium arsenate........450 gm. Water........25 gal.	16	13	16	14	15
5	Derrisol........375 cc. Calcium arsenate........450 gm. Water........25 gal.	12	10	11	12	11
6	Check (No treatment)........	16	16	15	14	15

When the yields in pounds of corms from Treatments 2, 3, and 4 of the table were compared with the check, no significant differences (7) were found. The remaining two sprays tested, however, gave significant reductions in yield when compared with the check. The burning was severe on the plants with the Paris Green - brown sugar treatment and the reduction in yield was about 33 per cent. The burning in the plots treated with Derrisol was not severe, and, therefore, the reason for this reduction in yield cannot be explained from the data at hand. However, this formula produced excellent wetting and a heavier coating of calcium arsenate was noted on the plants; therefore, it is possible that the white coating may have interfered with the physiological processes of the plants to such an extent that a significant reduction in corm production resulted.

With further reference to the burning of the plants, it should be pointed out that sprays containing calcium arsenate were considerably more toxic than those containing lead arsenate.

FIELD TESTS—1933

The field tests of 1933 were conducted on five varieties of gladioli; namely, 1910 Rose, Crimson Glow, Alice Tiplady, Francis King, and Scarlet Wonder. Each of these varieties was represented by a single row in each plot for every treatment and all treatments were replicated five times. Eighty corms per plot were used for the first three varieties, 75 for Francis King, and 40 for Scarlet Wonder. The varieties were arranged in the plots in the order given; i. e., 1910 Rose was planted in the first row and Scarlet Wonder in the last row of each plot. The corms, which were all quite heavily infested, were planted on May 19 and 20 and a good stand of each variety was obtained. Seven treatments were applied at weekly intervals with the same equipment used in 1932, except that the spray was discharged through two nozzles of the disk type instead of a gun. The nozzles were separated in such a manner that both sides of the row were sprayed simultaneously. As the plants increased in size, the nozzles were further separated. This arrangement minimized the possibility of mechanical damage by a driving spray and at the same time insured thoroughness of coverage. The first treatment was made June 13, when the plants were about 6 inches tall, and the last one occurred July 25, when some of the plants were in spike. Immediately after the last treatment, the plots were separated by barriers of burlap (Fig. 12). This was done to interfere with the migration of the adult thrips from one plot to another. The barriers were of particular value in those instances in which a treatment gave poor control, as well as in case of the check plots, inasmuch as they protected adjoining plots from infestation. This enabled us to place a more nearly correct evaluation on the effect of the several treatments.

Fig. 12.—Burlap barriers between plots in field tests to hinder migration of adult thrips

In addition to the types of data taken in 1931 and 1932, thrips populations were obtained by selecting at random two samples of five buds each from each variety in all the plots. In picking the buds, the second one beyond the last fully opened flower was chosen, after the method used by Richardson (18).

Of the various flower damage records taken (namely, percentage of infested florets, percentage of Grade 1 flowers, and percentage of salable flowers), it was found that the last named was the best measure of efficiency of the treatments. This was established by correlating the various damage records with the thrips population for each variety and in every case the correlation coefficient between the percentage of salable flowers and thrips population was higher than that for any other measurements. The percentage of salable flowers for each variety and each treatment is shown in Table 31. The other damage records are not considered in this publication.

In this table, it is apparent that Paris Green – brown sugar was superior to all other treatments, because in all five varieties of gladioli nearly all the flowers were salable; whereas this statement can not be made for any other treatment. Furthermore, this treatment was significantly (7) the best on all five varieties on which the tests were conducted, except Crimson Glow and Scarlet Wonder sprayed with the Goulac – Black Leaf 50 combination. In general, the Verdol – Black Leaf 50 and the Goulac – Black Leaf 50 combinations were similar in efficiency on all varieties. Verdol – Black Leaf 50 gave significantly better control on 1910 Rose than did the Cubor – lead arsenate combination; whereas the Goulac –Black Leaf 50 treatment of the Crimson Glow was better than either Red Arrow or Cubor used with lead arsenate. All the treatments reduced the flower injury significantly when comparisons were made with the check, but no other differences between the various treatments were noted aside from those indicated. Although Cubor and Red Arrow gave considerable promise in the greenhouse tests, these two sprays were not outstanding under field experimentation. The percentage of salable flowers in plots where nicotine dust was used was consistently lower than in those which had received nicotine in spray form, and, in most instances, the dust treatment was less efficient than the other materials used in the form of sprays. It is concluded that the sprays offer more promise as a field control, regardless of the fact that less extensive tests were conducted with the dusts. Inasmuch as the results, which are shown for each variety in the different sections of this table, so closely parallel each other, it is concluded that for practical purposes the various treatments gave a similar degree of protection to all five varieties of gladioli. Although, as mentioned before, the Paris Green – brown sugar spray does not wet well, it apparently leaves a sweetened arsenical residue which attracts the insects to feed on it. It is thought that the Goulac-arsenical combinations work in a similar manner to that described for Paris Green, but the results obtained with these sprays were not so favorable. Nevertheless, in the greenhouse tests it was found that Black Leaf 40 had considerable more residual value than Black Leaf 50 and it is probable that better results, in this experiment, would have been obtained from the Goulac and Verdol combinations if Black Leaf 40 had been used instead of Black Leaf 50.

The next criterion of efficiency of the different treatments to be considered is the final population records shown in Table 32. The values given in this table are the total number of insects observed on a sample of 10 buds taken from each plot.

In the varieties 1910 Rose, Crimson Glow, Alice Tiplady, and Francis King, all the treatments were significantly (7) better than the check. In the variety Scarlet Wonder, the only treatment which can be considered better than the check is the Paris Green – brown sugar spray. In Section E, of Table 32, showing the population on Scarlet Wonder, it may be seen that the number of thrips found for each treatment was considerably higher than the number found in any of the other four varieties. This increased population may be attributed largely to two reasons: (a) To migration of the insects from the earlier varieties of the series. This occurred after the spent foliage and flowers of the other sorts became less attractive; (b) Because the treatments were discon-

TABLE 31.—Percentage of Salable Flowers from Five Varieties in Field-sprayed Plots, 1933

Treatments	1910 Rose						Crimson Glow						Alice Tiplady						Francis King						Scarlet Wonder					
	Replications						Replications						Replications						Replications						Replications					
	1	2	3	4	5	M*	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M
Red Arrow ....150 cc. Lead arsenate...........204 gm. Water ....15 gal.	69	54	61	66	94	69	68	71	77	48	69	67	81	85	74	70	83	79	50	95	86	39	65	67	73	93	63	17	72	64
Goulac ....600 cc. Black Leaf 50 ....150 cc. Lead arsenate...........204 gm. Water ....15 gal.	43	64	87	100	80	75	79	58	90	84	100	83	76	62	77	82	81	76	77	33	75	79	89	71	63	57	77	93	71	72
Verdol ....284 cc. Black Leaf 50 ....150 cc. Lead arsenate...........204 gm. Water ....15 gal.	86	87	78	92	62	81	83	84	91	92	51	80	77	91	94	94	64	84	90	81	100	100	9	76	92	25	100	83	25	65
2% free nicotine dust	58	58	88	41	88	67	58	57	90	57	80	68	65	67	92	67	73	73	69	59	100	47	67	68	85	33	36	65	100	64
Cubor ....375 cc. Lead arsenate...........204 gm. Water ....15 gal.	75	27	58	57	86	61	63	61	55	58	86	65	65	80	75	70	96	77	57	74	42	84	82	68	57	88	45	63	95	70
Paris Green............141.8 gm. Brown sugar...............10 lb. Water ....15 gal.	100	100	100	100	100	100	98	97	100	100	100	99	100	98	99	100	99	99	100	100	100	100	100	100	78	100	100	100	100	96
Check (No treatment)...........	26	44	70	40	57	47	16	34	61	40	44	39	21	26	39	43	43	34	14	30	26	59	38	33	0	0	10	68	57	27

*M=Mean.

TABLE 32.—Index of Thrips' Population* in Field-sprayed Plots, 1933

Treatments	1910 Rose						Crimson Glow						Alice Tiplady						Francis King						Scarlet Wonder					
	Replications						Replications						Replications						Replications						Replications					
	1	2	3	4	5	M†	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M
Red Arrow .... 150 cc. Lead arsenate........... 204 gm. Water .... 15 gal.	162	144	175	227	90	160	153	112	154	222	86	145	85	96	121	97	63	93	90	41	33	202	120	97	91	90	426	439	253	260
Goulac .... 600 cc. Black Leaf 50 .... 150 cc. Lead arsenate........... 204 gm. Water .... 15 gal.	114	169	147	87	75	118	105	103	68	73	89	88	99	113	67	50	69	80	56	77	56	32	14	47	223	254	251	45	136	182
Verdol .... 284 cc. Black Leaf 50 .... 150 cc. Lead arsenate........... 204 gm. Water .... 15 gal.	75	109	102	189	159	127	46	76	38	29	219	82	50	30	32	39	194	69	17	32	32	40	183	61	92	166	26	78	458	164
2% free nicotine dust	129	144	75	205	111	133	126	116	26	154	114	107	129	83	18	85	125	88	72	113	20	127	73	81	178	258	94	334	39	180
Cubor..................... 375 cc. Lead arsenate........... 204 gm. Water .... 15 gal.	205	84	271	183	102	189	158	179	146	194	104	156	100	39	72	29	44	57	135	82	100	47	89	91	376	132	373	136	69	217
Paris Green .... 141.8 gm. Brown sugar............... 10 lb. Water .... 15 gal.	9	100	11	41	21	37	8	31	17	6	19	16	6	12	4	8	19	10	15	7	15	34	21	18	235	74	67	48	12	87
Check (No treatment)..........	438	178	147	457	190	282	363	272	158	241	261	259	521	334	216	145	95	262	237	159	228	156	166	189	638	881	896	115	371	580

*Each figure in this table refers to the total number of thrips found on a sample of 10 buds taken from each plot.
†M=Mean.

TABLE 33.—Corm Yield in Ounces from Field-sprayed Plots, 1933

Treatments	1910 Rose						Crimson Glow						Alice Tiplady						Francis King						Scarlet Wonder					
	Replications						Replications						Replications						Replications						Replications					
	1	2	3	4	5	M*	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M	1	2	3	4	5	M
Red Arrow ....150 cc. Lead arsenate...........204 gm. Water ....15 gal.	42	37	44	48	42	43	92	90	77	86	67	82	146	130	198	107	117	140	27	47	58	59	58	50	33	42	56	56	36	45
Goulac ....600 cc. Black Leaf 50...............150 cc. Lead arsenate...........204 gm. Water ....15 gal.	43	37	34	36	35	37	99	132	70	86	72	92	137	168	162	121	135	145	48	57	50	34	58	49	48	40	50	40	51	46
Verdol ....284 cc. Black Leaf 50............ 150 cc. Lead arsenate...........204 gm. Water ....15 gal.	40	32	37	36	52	39	84	102	66	66	71	78	104	144	108	124	140	120	48	48	48	24	64	46	34	26	42	51	41	39
2% free nicotine dust	36	45	50	36	42	42	127	103	84	100	71	93	155	117	135	132	122	132	70	56	32	67	56	56	32	44	32	56	37	40
Cubor ....375 cc. Lead arsenate...........204 gm. Water ....15 gal.	56	35	44	50	35	44	108	100	90	96	70	93	189	120	160	137	124	146	52	64	50	32	47	49	46	40	44	48	48	45
Paris Green............141.8 gm. Brown sugar .... 10 lb. Water....................15 gal.	31	29	40	31	42	35	116	90	76	88	68	88	142	84	110	135	138	122	60	40	37	29	47	43	44	39	42	43	52	44
Check (No treatment)...........	40	40	32	44	38	39	81	108	64	90	89	86	116	166	96	110	140	126	43	58	40	44	62	49	32	42	34	46	51	41

*M=Mean.

tinued long before Scarlet Wonder began to spike and the population remaining after the last treatment was allowed to multiply at will. For these reasons it is doubtful if the data pertaining to this variety should be considered of much value. On the other hand, the data emphasize the inadvisability of growers abandoning a program of field-spray control at a time too early to protect late-blooming varieties.

The outstanding treatment for all varieties in this test was Paris Green – brown sugar. This material was significantly (7) better than all other treatments on Crimson Glow. It was best also on 1910 Rose and Francis King, but this difference was less significant on the plots sprayed with Goulac – Black Leaf 50 and Verdol – Black Leaf 50 combinations. On Crimson Glow, the Goulac – Black Leaf 50 combination was significantly better than either Cubor or Red Arrow. These data, indicating the superiority of Paris Green – brown sugar as a control measure for the gladiolus thrips, are in keeping with the results obtained by Richardson and Nelson (18) with this treatment.

In general, the statement may be made that the differences between treatments in this experiment, where population of insects per plot was the criterion used in evaluating treatment performance, are not as great as indicated in Table 32, where numbers of salable flowers were used to differentiate the value of the treatments. It is concluded, therefore, that according to the data of this experiment, flower damage was superior to thrips population as a criterion of the performance of the materials.

In addition to the records discussed in the previous pages on the effect of the several treatments used in field-plot work in 1933, the weight of the harvested corms was taken. The corms were harvested during October and placed in a large greenhouse room to cure. During November and the forepart of December, the old corms and loose husks were removed. The weight of the corms from each plot is shown in Table 33.

In this table, it may be seen that in general the corms from the plots treated with Verdol – Black Leaf 50 and Paris Green – brown sugar weighed less than those from the checks. However, in no instance were any of these differences significant (7). On the other hand, the other treatments had a tendency to increase, rather than decrease, the yield when comparisons were made with the checks; therefore, it is concluded that no serious effect on corm production resulted.

RECOMMENDATIONS FOR CONTROL

Proper harvesting methods.—The first step in controlling the gladiolus thrips is the adoption of proper methods for harvesting the corms in the fall. The infestation in the growing plants may be very severe, but, if the proper procedure is followed at harvest, the corms may go into storage comparatively free from infestation; otherwise they may be polluted.

Immediately after the corms are lifted, remove the tops by means of pruning shears, leaving a short stub on the corm. During the topping process, do not hold the plants over the corm container as the insects will be shattered from the tops and will lodge on the corms in it. Promptly remove the corms from the vicinity of the planting and, if facilities are available, spread them out to cure before placing in storage.

Fall fumigation of corms.—In order to avoid any possibility of thrips damage during the storage period, some growers prefer to fumigate the corms in the fall. This practice is of particular merit if a storage room is not available in which a temperature as low as 40° to 50° F. can be maintained. Three fumigants are available for use: (a) Naphthalene flakes, (b) Ethylene dichloride (3 parts) – carbon tetrachloride (1 part); and (c) calcium cyanide. Of these materials, naphthalene in flake form is preferred because of its cheapness, efficiency, and safety and because one application results in the death of all stages of the insect. If properly used, it does not damage the corms; neither is it likely to harm the operator. A considerable element of risk to the operator attends the use of the other materials named, particularly the last. Naphthalene may be sprinkled over the corms in the trays in the storage at the rate of 1 ounce to 100 corms, or about 1 pound per bushel. If the corms are stored in paper bags, the naphthalene may be placed in the bag, after which the top is tied with a string. The corms should not be disturbed and the storage or other container should remain closed for a minimum period of 3 weeks in order to allow the fumigant to be fully effective. No harm will result if the naphthalene remains on the corms until all of it is evaporated, provided it is not used in larger quantities than recommended and that neither the sprouts nor roots start development before the naphthalene has disappeared.

Growers practicing fall fumigation should treat corms received from other growers before mixing them with the home supply. The reason is obvious. It is likewise advisable to treat all corms before marketing. The customer may have the good fortune to be free of thrips in his stock.

Store in cool room or outdoor pit.—If a storage is available in which a temperature of from 40° to 50° F. is maintained, fall treatment of corms is not necessary because the thrips will neither feed nor multiply under this condition. For small lots of corms an outdoor pit, such as described in this bulletin, is very satisfactory.

Burn refuse from storage.—Inasmuch as the gladiolus thrips does not normally hibernate out-of-doors under Ohio conditions, it is important to avoid infesting the plantings from insects which may escape from the storage. An important source of infestation is the husks which are discarded as the corms are worked during the winter and spring. These should be burned. In some instances it appeared that piles of husks thrown out doors beside the storage served as a source of supply for infesting the nearby plantings the following summer.

Importance of planting clean corms.—The evidence indicates that usually infestations on plants growing out-of-doors are started by planting corms infested with the thrips or that the insect spreads from nearby infestations on gladiolus. It is believed that plants grown from clean corms at some distance from other plantings will escape damage.

Spring treatment of corms.—Even if the corms have been fumigated in the fall, it is good insurance to treat them in the spring before planting. Mercuric chloride (corrosive sublimate) or Semesan may be used, but the former is preferred by most growers because it is a little less expensive.

A solution of mercuric chloride is made by dissolving 1 ounce in 7½ gallons of water. Earthenware or granite vessels should be used. The corms may be confined in burlap sacks and after soaking 4 hours they should be spread out to dry, unless they are to be planted immediately. If drying is necessary, care should be taken that the corms are not contaminated by thrips moving from untreated stock. The same bath may be used for additional lots of corms, but the strength of the solution should be brought back to par by adding ⅓ ounce of mercuric chloride and enough water to make 7½ gallons.

Summer sprays.—Regardless of the care a grower may take by way of attempting to aovid infestation by practicing sanitation and corm treatment, the growing plants may become infested, in which event summer spraying becomes necessary. Of the many sprays tested, the formula consisting of ½ pound of Paris Green and 33⅓ pounds of brown sugar in 50 gallons of water has given the most satisfactory results. The first application should be made as soon as an infestation is discovered, and the treatment should be repeated at weekly intervals until the flowers spike. Continuous agitation is necessary while applying this spray; otherwise, the Paris Green will settle to the bottom of the sprayer. It is well, under conditions of thrips infestations, to cut the flowers promptly inasmuch as the flowering spike affords the best opportunity for multiplication.

Inasmuch as it has been observed that a hard, dashing rain destroys many of the thrips on growing plants, it is suggested that occasionally syringing infested plants with a coarse driving spray from the garden hose may offer some degree of relief for the grower who has only a few plants to treat.

SUMMARY

The gladiolus thrips appeared simultaneously in Ohio and Ontario, Canada, in 1929. During the past 4 years it has become widely distributed in North America and is the most serious pest of gladioli.

Every part of the plant except the cormel or bulblet is subject to attack; the flower spike suffers the greatest injury, and the loss in cut flowers alone may amount to from $1500 to $3000 per acre. In addition, the loss due to injured corms and stunted corm growth are items of no small moment to the grower.

The various stages of the gladiolus thrips consist of the egg, two larval instars, two pupal instars, and the adult. A description of the various stages is given.

Parthenogenesis in this species of thrips may occur and the progeny in all such cases noted were males. Because of the polygamous habits of the males, it is probable that very few unfertilized females occur normally.

Hibernation in Ohio occurs largely, if not entirely, on the corms in storage. No insects were observed to survive the winter out-of-doors.

The development of all stages of the gladiolus thrips on corms in storage was accelerated with an increase in temperature. The developmental period of all stages for five different temperature levels is given.

The developmental period of the various stages in the field is similar to those reported by Smith and Nelson (22). During the period from June 10 to October 15, 1932, nine generations were reared in the insectary at Wooster, Ohio. Additional generations may have developed in the field before June 10.

Both adult and nymphal stages are secretive in habit and quite sluggish in movement in comparison with some other species of thrips. Considerable migration occurs, however, under heavy infestation conditions.

Natural infestations of gladiolus thrips have been found on Japanese and German Iris, Calla Lily, Montbretia, Torch Lily, and Tiger-flower. It has been taken on many other flowers and plants both in the field and the greenhouse.

Only one natural enemy was observed and this is not significant. Heavy rains, however, perceptibly reduce thrips population on growing plants.

Resistance and susceptibility to thrips attack were demonstrated among gladiolus varieties.

Proper methods of harvesting corms in infested plantings aid materially in the control of this pest.

Proper methods of storage where low temperatures are maintained prevent injury to the corms.

From the standpoint of the small grower, an outdoor pit storage offers promise.

Thorough treatment of the corms in storage with naphthalene flakes, ethylene dichloride (3 parts) – carbon tetrachloride (1 part), and with calcium cyanide will insure clean corms. The most favorable results were obtained by treating the corms in small lots before they were placed in storage in the fall.

If treatment is delayed until spring, the insecticidal dips, mercuric chloride (corrosive sublimate) and Semesan, should be used.

Other fungicidal dips, such as Calogreen and calomel, did not give 100 per cent control when used as recommended for the control of diseases.

None of the corm treatments which are recommended showed any ill effect on subsequent corm development if the corms were dormant when the treatment was applied.

The outstanding field treatment is a weekly application of a spray consisting of Paris Green (½ pound) and brown sugar (33⅓ pounds) to 50 gallons of spray.

Slight burning occurred when Paris Green was used at the rate of ½ pound to 50 gallons, but burning was severe when 1 pound was used.

Some varieties of gladioli are more susceptible to spray injury than others.

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